Radio

SERVICE DEALER

$2 PER YEAR

OCTOBER 1943

RADIO-ELECTRONIC MAINTENANCE

Radio SERVICE-DEALER

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MEMBER AUDIT BUREAU OF CIRCULATIONS

Vol. 4, No. 10 ★ October, 1943

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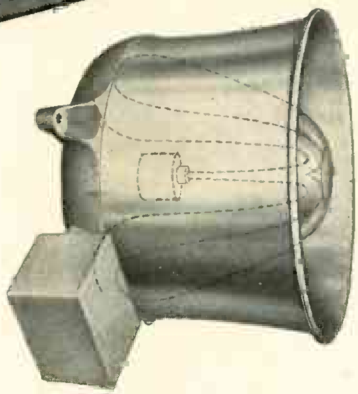

The RACON Marine Horn Speaker is used both as a loudspeaker and as a microphone. Approved by the U. S. Coast Guard for all emergency loudspeaker systems on ships. A double re-entrant type speaker, completely waterproofed and weatherproof. Ideal for general P.A. and Marine use. Several sizes available. RACON Permanent Magnet Horn Units are available in operating capacities of from 10 to 50 watts.

In judging the value of sound reproduction equipment, the month-after-month, year-after-year dependability and efficiency of loudspeakers are prime considerations along with fidelity, output and initial cost.

RACON has never compromised with quality. RACON Speakers and Driving Units are recognized as the standards by which other loudspeakers are judged. RACONS are used on U. S. Army Transport and Navy vessels — by other branches of the Military — in warplants, shipyards, etc. RACONS are available for every conceivable application. Specify RACON when planning your next sound or public address installation.

RACON ELECTRIC CO., 52 East 19th St., New York, N. Y.

RACON

editorial . . .

BATTERY BLOOMER

★ The *N. Y. Sun* published the following item in Mid-September: "Volunteer amateur radio operators serving with the War Emergency Radio Service in New Jersey and New York will have 56,153 batteries made available to them, Sinclair Hatch, regional director of the Office of Civilian Defense in New York announced. Other replacement parts for radio units will be made available, also.

"Mr. Hatch said that the batteries will make it possible to place into service manv radio units now idle. They will also provide auxiliary power for those units solely dependent upon power from commercial power lines. There are 235 WERS units in New Jersey and 765 in New York State."

Think of it! OCD has obtained, for only 1000 WERS, over 56,000 batteries which are to be used "to place in service many rigs now idle" or which must have "auxiliary power—as they are dependent upon power from commercial power lines." As though eastern power lines "go out" frequently! In the meantime, hundreds of thousands of farmers and important war workers who reside in absolutely non-electrified areas must go without vital radio news, weather, crop, and price reports. They are not able to obtain—not auxiliary power—but *basic* power for their radios. In New York and New Jersey there is practically no important unelectrified section, besides which the WERS batteries are intended for mere auxiliary use.

Do not be misled about OCD and WERS. Both are estimable. But the "timing factor" as to their requirements and the services they render must not be overlooked. In our opinion, the OCD and such agencies do not represent vital factors in the war effort at this particular time. We gripe at the obviously bad judgement of someone, somewhere, who has the temerity to allocate possibly ten or twenty times too great a quantity of batteries to an *auxiliary* group—yes, a group that is basic neither in defense nor in promotion of offensive war endeavor, all at the expense of unregimented farmers and ruralites who are, in most instances we believe, far more deserving and who should have any special battery allocation that can possibly be arranged by the WPB right now.

BLACK MARKET IN TUBES

★ Few will be surprised when we report that a Tube Black Market exists. Between September 7th and 10th our representatives visited 28 retail radio stores in New York City's "Cortlandt Street area"—and many other typical cut-price stores in Philadelphia and Boston. Practically every one of these cut-price stores had for sale, at list prices, reasonably large quantities of every type of tube, even the scarcest types. One Cortlandt Street dealer openly stated "we can get all the tubes we want, and so can you, if you know how to go about it and are willing to pay the price." Our investigators admittedly did not have to pay more than list price for any tube purchased, and only token purchases were made in several instances.

Our investigators called upon a total of 100 stores, 50 in the cut-price, and 50 in the standard price category. Of the cut-rates, only 13 would accept repair jobs offered. Of the standards, all 50 were perfectly willing to accept a repair job. Bear in mind that our investigation was made on a "cold-canvass basis" with no foreknowledge of any store's character, except whether it was classified as a cut-price or standard practice establishment.

Of the 50 standard stores interviewed, only 9 had what would be called "fair" tube inventories. Only 13 had limited quantities of semi-hard-to-get tube types. Not one standard store had any 50L6's, 35Z5's, 12SQ7's, etc. Some had just received a small number of "MR" tubes, none of which was a "scarce" type.

We do not know how or why the obvious maldistribution situation exists. We cannot substantiate that any dealer paid Black Market prices for whatever tubes he had. We do emphatically suggest that *a governmental investigation should be instituted at once!* If need be, and we make this suggestion with full realization that it may sound Anti-Democratic, especially coming from a 5th generation American—yes, we suggest that all dealers found guilty of being tube hoarders, and those who obtained tubes in an unethical fashion, should have their entire tube stocks sequestered and confiscated. Such tubes, in turn, should be redistributed amongst ethical and legitimate service-dealers who can quickly put them into the millions of civilian receivers which are now idle because of the supposed unavailability of replacements.

LATEST NEWS ON "MR" TUBE PRODUCTION

★ Tentative plans now call for the production of 1,000,000 "MR" tubes of the 15 most needed types, between Sept. 1st and Jan. 1st, with the usual WPB joker, "if facilities are available after the military demands are met." What a come-down! Only a few weeks ago Washington tried to kid us, and the public, by saying that 2,000,000 tubes for civilians were being made each month. We pricked that fanciful balloon, but—what's more important is this: Will service-dealers, and through them civilians, get the 1,400,000 tubes or is this merely some more soft-soap? Who's kidding who? And in closing, let's remind you that WPB has revised its previous order which provided that all "MR" tubes had to be sold *only* to non-priority holders. Since Sept. 7th, the modified order provides that tube manufacturers must notify WPB if military priorities jeopardize civilian deliveries, in which event materials intended for "MR" tubes can be diverted to other tube production.

For still further information about the tube and battery situation, read page 27 in this issue.

One answer to your radio service problem—

a new handbook that helps your newer radio service people to help themselves

Just off the press, "The ABCs of Radio" is a helpful new book prepared by General Electric to aid you in training your radio service people. Packed with valuable information, this 68-page, fully illustrated book presents the fundamentals of radio, written in language the beginner can understand.

This book is the outgrowth of a training course prepared by the General Electric Company for radio service beginners, radio salesmen and students.

The scope of the material is broad and it is treated from the standpoint of the practical service man rather than the advanced radio engineer.

Here are some chapter headings in this new book:

Symbols and Abbreviations, Wave and Electron Theory, Direct Current Theory, Inductance Theory, Magnetic Induction Theory, Electron Tube Theory, Radio Communications System, Rectifier and Power Theory, Antenna and R. F., Oscillator and Converter, Test Equipment, Trouble Analyzing and Corrections . . . (speaker stage, R-F amplifier stage, etc.).

For service men, salesmen and students of radio—here's a new book that's really worth while. Costs only twenty-five cents a copy! Send for your copy today . . . fill out and mail coupon to *Electronics Department, General Electric, Bridgeport, Connecticut.*

ELECTRONICS DEPARTMENT
GENERAL ELECTRIC, BRIDGEPORT, CONNECTICUT

I am enclosing__________for which please send me__________ copies of the new 68-page book, "The ABCs of Radio," at twenty-five cents per copy.

NAME__________________________________

ADDRESS__________________________________

CITY__________________________ STATE__________ D

GENERAL ELECTRIC

176-B5

Audio Amplifier Stage Repairs

by Oscar E. Carlson

★ Radio service-dealers are well aware of the similarity that exists between the thousands of radio models that were sold in recent years. Due to this similarity, there are many ways in which he can accomplish some desired result in a receiver. Bearing this in mind, we realize that the radio service-dealer of today must more than ever be a "Radio Service Engineer" to successfully alter or re-design some portion of a receiver due to the inability to obtain some replacement parts.

When a substitution or change is made in a radio receiver, the service-dealer should by all means record that data by schematic indication and a written record. One copy of such data should be attached to the receiver for the benefit of the next fellow who must service that set and one copy placed on file for future reference. This is good common sense since we may all have to repair receivers altered by some other service-dealer. *Fig. 1* illustrates a sample of a record card that may be used for such cases.

In this article we shall deal briefly with repairs to the audio amplifier section of radio receivers. That the same methods apply to public address equipment can readily be seen.

A common fault in older type receivers is the failure of the audio transformer primary or secondary. *Fig. 1* illustrates a change that may be made to utilize a transformer that had an open primary. If the secondary had been open instead of the primary, the circuit would be altered as shown in *Fig. 2.*

Push-pull input transformers are another notable source of trouble and are usually used in such circuits as shown in *Fig. 3.* This is a conventional older type receiver still found in great numbers today. *Fig. 5* illustrates the use of a push-pull input transformer with an open primary winding. *Fig. 4* illustrates a method of replacing the push-pull input transformer with another tube, or phase inverter stage. This can usually be done by mounting the new tube, a triode, in the space formerly occupied by the transformer. The cost of components for such a change will not exceed that of a transformer. The fidelity may be greatly improved by such a change and is therefore often advantageous.

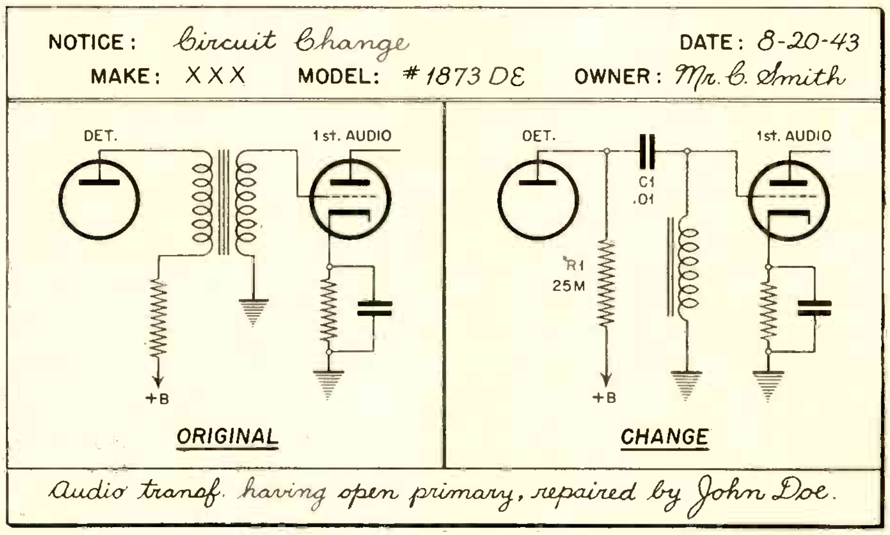

Fig. 1. Circuit Change Record Card.

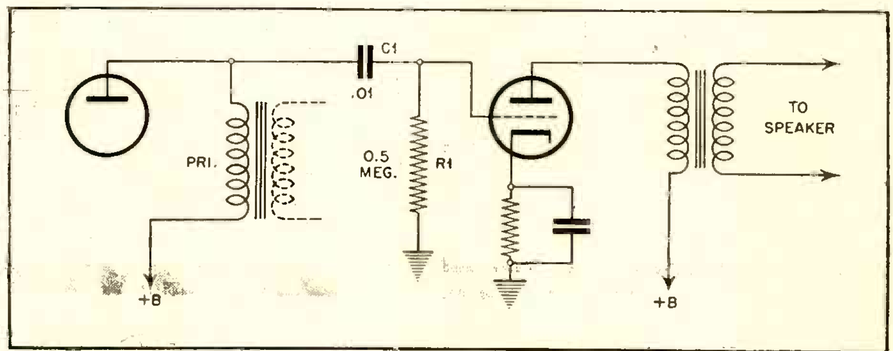

Fig. 2 Method of utilizing audio transformer having an open secondary.

Interstage Transformer Failure

Many present day receivers employ push-pull pentode output tubes. Failure of the interstage transformer of such receivers is one of the service-dealer's headaches today. A satisfactory solution is to substitute a phase inverter circuit. A phase inverter tube may be added as shown in *Fig. 4* for triode output tubes by proper selection of component values, or, a simpler method may be used. This method is shown in *Fig. 6* and requires no extra tubes.

As is well known, the screen circuit of a pentode tube is a portion of the plate circuit and thus has a 180° phase relationship to the grid circuit. Philco has employed this fact in some of their later model receivers to obtain push-pull amplification without an extra tube for phase inversion. The circuit shown in *Fig. 6* may be applied to most pentodes by proper choice of circuit constants. The audio voltage is delivered to *T1* from the driver stage and amplification takes place in the usual manner. An extra resistor *R1* is connected to the screen circuit of that tube. A small portion of the output voltage is developed across that resistor and fed to the grid of *T2* through the coupling capacitor *C1*. The output voltage from *T2* will then be 180° out of phase with the output voltage of *T1* since their respective input voltages are 180° out of phase.

The value of *R1* must be chosen so that the audio voltage delivered to the grid of *T2* will be the same as that delivered to the grid of *T1*. If *T1* has a gain of five times, we should apply to the grid of *T2* only one fifth the output voltage of *T1*. The value of *R1* can be ascertained by applying a constant input signal and using an oscilloscope to measure the output voltage in *T2* and *T1*. The output voltage of each should be the same. For information relative to the use of the oscilloscope for such measurements see RADIO SERVICE-DEALER for *May, 1943*. A 10,000-ohm potentiometer may be used in place of *R1* to determine the proper value of *R1*. When the proper balance of output voltage is obtained, the potentiometer resistance may be measured and a resistor of that value placed in the circuit. The values shown in *Fig. 6* are for push-pull 6F6 tubes. For other tubes, the value of circuit components other than *R1* may be readily determined from a tube manual such as RCA Technical Series RC-14. For most pentodes, grid resistors of from ¼ to ½ megohms will be satisfactory when self bias is used.

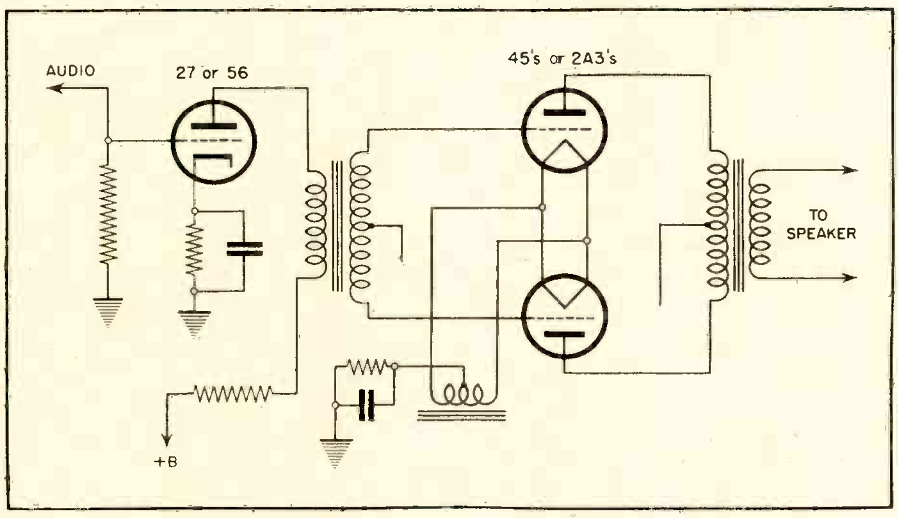

Fig. 3. Conventional driver and push-pull power stage of older home receivers.

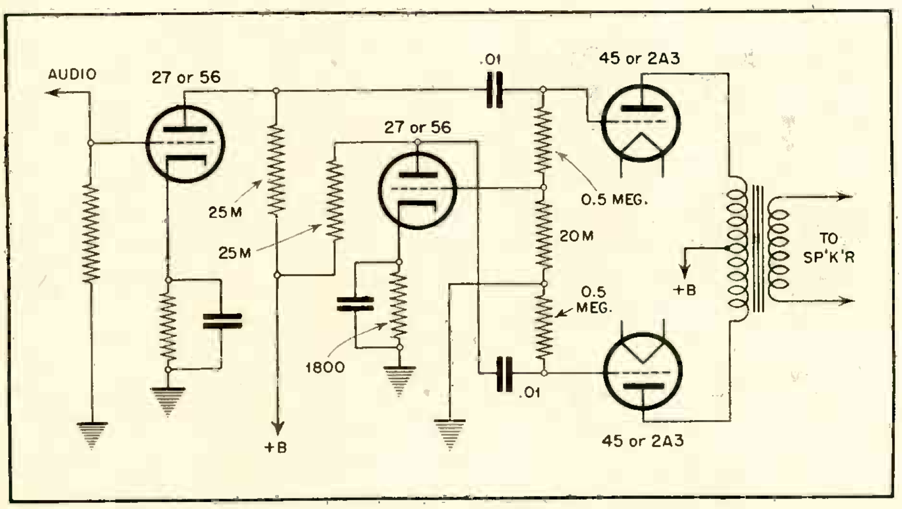

Fig. 4. Push-pull input transformer replaced by phase inverter circuit.

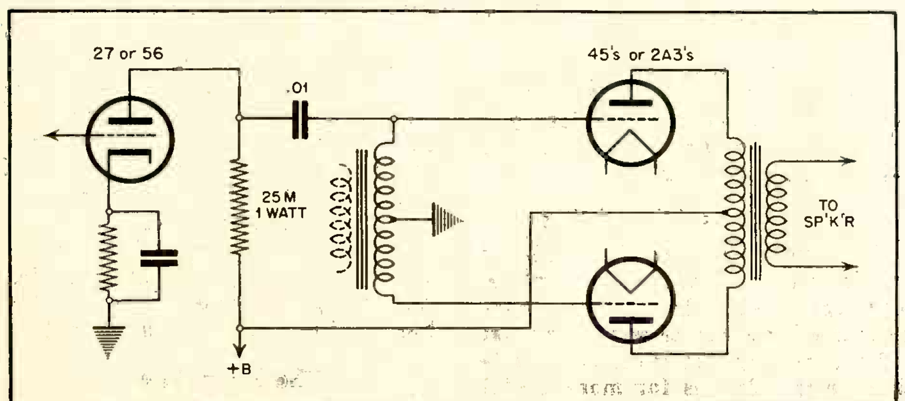

Fig. 5 Method of utilizing interstage transformer having an open primary.

Audio Coupling Stage Breakdown

Another common source of trouble in audio amplifier stages is the audio coupling capacitor. This capacitor, usually of the paper by-pass type, develops low leakage resistance, thus placing positive voltage on the grid of the following tube. This results in distortion and if the leakage is low enough the following tube is oftentimes damaged by the resulting flow of excessive plate current. Capacitors that develop a leakage resistance lower than 200 megohms are usually unsuited for use as audio

(Continued on page 27)

RADIO MECHANICS

Part II

by John H. Potts

★ In the first article of this series, we discussed some of the factors involved in the selection of taps, drills, and soft solders for radio servicing together with the difficulties arising from combinations of dissimilar metals. In this article we are going to take up some of the more special problems of a mechanical nature with which we are often confronted in repairing or installing radios. Before doing so, let us devote a little space to our shop layout and bench equipment. Often slight changes in the design of the work bench, or the location of the tools, may make a great difference in the amount of work one can turn out without tiring.

Constructing The Bench

In general, the work bench should be constructed with heavy planks, at least two inches thick, for the top front. The back part of the bench, nearest the wall, does not normally carry such heavy loads and therefore thinner planks may be used, though it is a good idea not to use any planks less than an inch thick. The depth of the bench should not be more than thirty inches. If greater than this, the bending to reach tools and other items at the back of the bench may tire the worker quickly.

The height of the bench, from the floor to the top surface, should be from thirty-four to thirty-six inches, depending upon the height of the user and the nature of the work. If heavy work is to be done, such as filing, drilling, bending, etc., the bench should be somewhat lower so that the weight of the body may be used to reinforce the muscular effort. For light work, such as soldering, trouble-shooting, and general parts replacements, it is better to have the work higher, so there will be no need to bend the back while at the bench. It is a good idea, if space permits, to have two benches; one for heavy work and the other for lighter work, each designed for the purpose. By confining all metal work, such as cutting, drilling, grinding and filing to one bench, the possibility of metal filings getting into the chassis or speaker is minimized.

The very efficient service bench built by W. R. McGriff.

The Vise

One of the most important accessories for the work bench is a good vise. In most radio shops, the vise is often a poor, under-sized affair, totally inadequate for rapid and efficient use. Once you have worked with a good, husky vise, preferably one which can be swung in any direction and locked in position, you will appreciate what an advantage this "third arm" has.

About Drills and Drilling

We have mentioned the need for an electric drill in the first article. Although a bench drill is much more desirable for accurate work, for most radio servicing applications a portable electric drill is far more useful since it can be used in places inaccessible with the bench-type drill. In choosing a portable drill, one which will take up to ¼-inch drills is preferable for most radio work to the larger and more expensive types because of its lightness and ease in handling. Of course, if one can afford both, so much the better. In general, the larger holes are most safely drilled with a brace after starting with a small drilled hole when working in crowded quarters on a small chassis. Remember, too, that high-speed steel drills are required for electric drills. These are now hard to obtain, particularly in the larger sizes. If ordinary drills are used in an electric drill the heat developed in hard metals is often sufficient to draw the temper and thereby render the drill useless.

Grindstone Uses

A small power-driven grindstone is another essential for the well-equipped radio shop. This not only provides a means of keeping drills and other tools sharp, but may also be used for making "flats" on control shafts and similar strictly radio repair operations.

Socket Holes

Making holes for sockets is another operation frequently required in radio shop repair work. For thin metal chassis, 20 to 24 gauge, a standard punch and die work well. But for the heavier chassis, up to 16 gauge, it will be found better to use a circular saw type of cutter. Still better, in this writer's opinion, is the screw-operated type punch and die. This requires no pounding to cut the hole; by simply tightening a bolt which passes through the punch and die, and the guide hole made in the chassis, the socket hole is formed.

The Hack Saw

In choosing hack-saw blades—and it is well to have a variety on hand

SPRAGUE TRADING POST

A FREE Buy-Exchange-Sell Service for Radio Men

WANT TO BUY — All of Rider's Manuals, Vacuum tube voltmeter, other Rider books and Radio-Craft magazines. Radio Electric Service, Lemongrove, Calif.

FOR SALE—#562 Supreme audolyzer. J. O. Reese Radio Service, Franklinton, La.

TUBE TESTER WANTED—Must test all late tubes. Prefer RCP comb. tube and set tester. Pratt Radio Sales, 136 Murphy St., Sunnyvale, Calif.

RCA SIGNALYST WANTED—State condition and price. Fox Radio Service, 435 So. 5th St., Richmond, Ind.

WANTED FOR CASH OR TRADE—Supreme Audiolyzer and following Superior instruments: #1220 pocket lab., utility tester, dynarometer or xrayometer. Any AC-DC V-O-M; AC all-wave signal generator, and 2" 'scope. State make, model, ranges, age, and exact condition in first letter. Have test equipment, sound eqpt., radio parts, etc. to trade if you prefer this to cash. Grey's Radio & Sound Systems, Inc., Bridgewater, Conn.

WANTED — Will pay cash for portable radio and record player combination with short wave and microphone. Must be in good condition. Cpl. Herbert O. Muston, Jr., Telegraph Office, South Camphood, Texas.

WANTED—Will pay cash for set of short wave coils, or trade for other radio parts. H. Gursh, 1481 Shakespeare, Bronx, New York 52, N. Y.

WANTED FOR CASH—Astatic FP-8 or AB-8 pickup arm. Must be in good condition. Cartridge not necessary. Cpl. A. J. Holton, Inf. Band No. 1, Camp Roberts, Calif.

WANTED—for cash or trade: Eimac 50T, 150T, 300T tubes. David Steele, 219 Elm St., San Mateo, Calif.

WANTED — Signal generator, any type other than battery-operated. Will pay cash. P. L. Hennessy, 906 W. 11th St., Coffeyville, Kans.

SWAP OR SELL—Hallicrafter SX25 with Jensen bass reflex speaker. Like new. Also have Browning 5-band pre-selector. H. Mandel, 2178 Tiebout Ave., Bronx, New York, N. Y.

WANTED — We need microphone cable: rubber-covered, single shielded. Also need Amphenol connectors MCIP, MCIF, and MCIM. Will pay cash or trade parts of all kinds incl. P.A.'s and P.A. eqpt. Also have some new inter-office com. eqpt. Stapleton's Radio Service, 632 Quincy St., Topeka, Kans.

WANTED—Neon sign "Radio Repairs." Give full details first letter. Rose-Bud Radio Service, Ripon, Wisc.

BUG WANTED—for international code. Will pay cash. Pfc. Wilbur K. Briscoe, Hq. Co. 1st Bn. 22nd Marines, c/o Fleet Post Office, San Francisco, Calif.

WANTED FOR CASH — Condenser checker in 1st class working condition such as Sprague, Solar, C-D, Jackson, etc. Also want a portable phonograph motor 78 r.p.m. for use with P.A. system. Give full details. George Keefe, 4937 Chancellor St., Philadelphia 39, Pa.

WANTED—One phonograph amplifier for cash, or will trade for 4 misc. tubes, filament, power, speaker and A-F transformer, a single and double-gang tuning condensers and other misc. eqpt. S/Sgt. Jessie E. Jones, 320th Hq. & Hq. B-T6, C.A. A.F., Carlsbad, N. M.

WANTED—RCA 161 Signalyst, also model 165 Jr. VoltOhmyst. Will pay cash. National Radio Service Co., 625 Main St., Worcester, Mass.

EQUIPMENT WANTED — Will pay cash for low-priced signal generator, channel analyzer, and tube checker. Describe fully. Roland W. Fordham, 4 Harvey Court, Waterbury, Vermont.

FOR SALE—D104 crystal mike, $16, or will trade for portable typewriter; Cardwell variable xmitting condenser XT210PD, $6.50; Hammarlund variable xmitting condenser TCD-100X, $6.50; banjo mandolin and case, $4.50, and watt hour meter AC house type $7.50 or trade either for 22 rifle; 12" 10 lb. recorder turntable, screw, magnetic recording head, needs fixing, $20. Write for details. Al. R. Dayes, 1418-81st St., Brooklyn, N. Y.

TUBES FOR SALES—All in original cartons: 4-1C6; 3-2A5; 6-2A6; 6-2A7; 6-2B7; 4-6A4; 1-6A6; 2-6A7; 2-6F7; 2-46; 2-59; 1-49; 2-89; 1-55; 2-56; 2-57; 10-58; 6-2A3; 2-5Z3; 5-10; 5-50; 2-12A; 6-201; 3-226. Mostly special brands. Will sell all or part at lowest net prices. J. C. Thimijan, 715 N. 7th St., Lake City, Minn.

TUBE TESTER FOR SALE—Triplett #1210-A unit in A-1 condition. Will sell for cash, or will swap for late V.O.M.A.M. 25000 O.P.V. — at least 10 meg. Jack's Radio Service, 196 Lincoln St., Millinocket, Me.

WANTED—Speed Control turntable phonograph motor. Also interested in other radio parts. What have you? Joseph Hall, Box 58, Middleton, Mass.

URGENTLY NEEDED — V-O-M for AC and DC. Also interested in late model tube tester and other service tools and eqpt. Describe fully & state lowest cash price. Southern Engineer Associates, Ltd., P.O. Box 25, Le-May Station, St. Louis 23, Mo.

WANTED — Used communications receiver and ham transmitter; also, set of Rider Manuals, oscilloscope, and other test eqpt. Michael Bratkowsky, 95 Balsom Ave., Bridgeport, Conn.

SALE OR TRADE—Supreme diagnometer #585, like new. Walt's Radio Shop, 11449½ Longbeach Blvd., Lynwood, Calif.

TUBES TO TRADE—Will swap hard-to-get types for any model Hallicrafter receiver. Wright Radio Service, 201 N. 5th St., Leavenworth, Kans.

WANTED — Late model communication receiver; also Voltohmyst. Sgt. Carroll E. Anderson, Troop C—107th Cavalry, Santa Rosa, Calif.

WILL SELL—used RCA station allocator, $15 plus postage; used free-point analyzer, cable & plugs, $4. Wanted at once for W.E.R.S., Abbott DK-3 2½-meter transreceiver (will pay up to $30); Abbott TR4 2½-meter transmitter-receiver (will pay up to $50 with tubes); HY-615 and HY-75 tubes. Wm. D. Montgomery, 1290 Coolidge Ave., Cincinnati 30, Ohio.

WANTED—Good, portable AC operated tube tester for all types. Would like one that reads "Good" and "Bad", but not essential. Randolph McDonald, 1410 Rio Grande St., Austin, Texas.

WANTED—Will pay cash for Superior signal generator. Halls Radio Service, 6005 W. Fairview Ave., Milwaukee 13, Wisc.

WANTED—Used set of Rider's Reference Manuals Vols. 1-14 incl., also latest model tube tester. John Cogill, 616-6th Pl., S.E., Mason City, Iowa.

SPEAKER WANTED—Jensen #JH P-52 or Utah co-axial type. Must be in good condition. Packard, 84 Greene St., Pawtucket, R. I.

WANTED — Tube tester for late types, also V-O-M. Richard Griffin, 210 Boyer St., Gallatin, Tenn.

WILL BUY used radio diagrams, books, or radio circuit manuals published within past 3 years. L. A. Verdiales, P.O. Box 5, Vieques, Puerto Rico.

NEW TUBES FOR SALE — 1Q5GT; 1A6; 1B5; 1C6; 1D5G; 1D7G; 1F6; 1J6G; 6Q6G; 6W7G; 33, 34, 38, 39/44, 46, 79, 89, 20, 22, 183/483—price 25% under list. Send small deposit and supplier's certificate with order. Also have 4" Kurz-Kasch dial @ 30c; Hammarlund Var. Condenser types MCD, SM-100, and MC-20S @ 50c ea.; and impedance coupling transformer, 50c. N. J. Cooper, 4617 N. Damen Ave., Chicago, Ill.

TO SELL OR SWAP—Weston #506 DC O-1 Ma. permanent magnet moving coil type, new meter. Also have other parts—send for list. Best cash offer or swap for photo eqpt. John J. Vilkas, 1515 So. 48th Court, Cicero, Ill.

WANTED—Two National type ACN dials; two midget tuning condensers, dual, 35 mmf. per section, gangable, Bud #913 or equal. Emory A. Cox, 618 S. Roberts, El Reno, Okla.

AMPLIFIER FOR SALE — complete 40-watt amplifier for sale or trade for good oscillograph. Amplifier has 1 Turner mike 44X, 2 PM Utah speakers F12P and built-in turn table. Miles Radio Serv., Loyal, Wis.

WANTED—Multimeter, signal generator (oscillator) and an omission tube tester. Joe Tyson, 407 K St., N.W., Washington 1, D. C.

YOUR OWN AD RUN FREE!

The "Trading Post" is Sprague's way of helping radio servicemen obtain the parts and equipment they need, or dispose of the things they do not need during this period of wartime shortages. Here then are a few hints which may help you benefit from it:

Answer interesting ads while they are "fresh." Don't wait until the magazine is several weeks old. Do not send letters in reply to advertisements to Sprague. Write direct to the advertiser.

Study the "For Sale" ads first to see if what you need is listed **before sending in your "Wanted to Buy" ad**. The Trading Post appears regularly in Radio Retailing-Today, Radio Service-Dealer, Radiocraft, Radio News, and Service.

Please do not specify the magazines in which you would like your ad to appear. We'll do our best to get it in one of the leading publications, but it only complicates matters when a certain publication is specified.

Please don't ask us to run an ad in which you ask more than the normal price for parts or a piece of equipment.

Don't offer to accept C.O.D. telegraphic or telephone replies to your ad. Some individual Trading Post classified advertisements have pulled as many as four and five hundred answers!

Answer ALL inquiries to your advertisement promptly — even though some of them may have arrived too late. This is only common courtesy.

When sending your ad to Sprague, please address it to the department number shown below. This serves as a valuable guide to our advertising department.

Obviously, ads featuring equipment "For Sale or Trade" generally bring better results than those wanting to buy hard-to-get equipment. Preference will thus be given to ads offering parts or equipment for sale.

Write your ad carefully, clearly, and keep it short. Many ads received are unintelligible or hard to decipher—and this causes unnecessary trouble.

"Emergency Ads" will receive first attention and Sprague, of course, reserves the right to eliminate any ads which do not seem to fit in with the idea behind this special wartime emergency advertising service.

DEPT. RSD-310

SPRAGUE PRODUCTS CO., *North Adams, Mass.*

SPRAGUE CONDENSERS
KOOLOHM RESISTORS

Obviously, Sprague cannot assume any responsibility, or guarantee goods, services, etc., which might be exchanged through the above advertisements

TABLE I

BRAZING ALLOYS

Percentage Copper	Zinc	Tin	Lead	*Characteristics*	*Melting Point (°F.) (Approx.)*
58	42	—	—	Very Strong	1630
53	47	—	—	Strong	1620
48	52	—	—	Average	1598
34	66	—	—	Melts Easily	1500
55	26	15	4	White Solder	——

—remember that the ones with the fewer teeth per inch are for soft metals, such as aluminum alloys, zinc, etc. The types with more teeth per inch are for hard metals, such as iron and steel. For the latter, more pressure is needed to cut, and the increased number of teeth distributes this pressure over a number of points and thus reduces the strain on each tooth. For softer metals, this added strength is not required and the increased space between each tooth enables rapid cutting without the clogging of the teeth with the cut metal chips.

The File to Use

The same remarks apply, in principle, to the choice of files. For heavy, rough work on soft metals, a coarse file should be used because a fine file will quickly clog up under such conditions. And, in filing, remember to file in one direction only —away from you. The file should be held with both hands and lifted from the work on the return stroke. If much soft metal is filed, it will pay to have a file brush to clean the file teeth occasionally. A double-cut, bastard flat file is about the most useful general purpose file for most metals (other than aluminum) encountered in radio work. For aluminum, a rough or coarse cut is generally preferable for heavy work, although finishing may be done with the somewhat finer bastard cut. Other grades of cut are second-cut, smooth, dead-smooth, and super-smooth. As the names imply, each cut is progressively finer than the preceding listed type. The single-cut types have the teeth all parallel and at the same angle; the double-cut file has its teeth arranged in two rows which cross each other at an angle. There are also rasp files, which have individual raised teeth, and are used for very rough work on soft materials. The selection and use of files is quite an art in itself which requires considerable skill and experience. Fortunately, in radio repair operations, only elementary filing operations are involved, and a complete study of files and their applications is therefore beyond the scope of this article.

Should a Lathe Be Used?

Under ordinary conditions, there is seldom enough work around a radio shop to justify the expense of a lathe. In fact, in some instances the lathe is a hindrance rather than a help in the successful operation of a radio repair business. This comes about because the user is often inclined to spend time at the lathe which might more profitably be spent at strictly radio work. In general, where it is possible to purchase a manufactured part, there is seldom any justification in attempting to make it. The cost of the manufactured part will almost invariably be less than the value of the time spent at the lathe in making a substitute. There are exceptions in cases where the shop is located at some point remote from any source of supply for parts or, as at present, when manufactured parts of any description are often difficult to get.

Aside from turning and drilling operations, for which the lathe is especially fitted, this machine may be used for winding many of the simpler forms of coils, such as are required in power or output transformers. With the addition of special forms and gear trains, it is also possible to adapt the lathe to winding universal-type coils, as required for i-f transformers, etc.

Drilling Operations

Among the tools which radio men need, but seldom have, are star drills. These are used for forming holes in cement, concrete, brick and plaster, into which expansion bolts may be inserted. One of the reasons why most antenna installations are such botch jobs is largely due to the wholly inadequate methods employed in the anchoring of wires along brick building walls and in the plaster of the room interior. By making these holes with the star drill, and using expansion bolts or other type bolts designed for plaster work, a good mechanical support will be obtained. In some cases, it is possible to do a fairly passable job by driving split knobs into the concrete on building exterior walls, but in general, this method will always be far inferior to an expansion bolt mounting. If attempting to use split knobs in this manner, it will be found best to tap the head of the nail gently with the hammer rather than hitting it hard as so many do. The latter method simply dulls or bends the nail and chips the concrete. On the other hand, by taking the work slowly as described, the nail gradually penetrates the mortar without excessive chipping.

While we are on the subject of fastening lead-in wires to brick walls, we want to call to the attention of those who are new to this kind of work that wires which are brought through brick walls should pass through porcelain tubes. The hole for these tubes may be formed with the star drill through the mortar or brick and that portion through the wood wall is drilled with

TABLE II

SILVER SOLDERS

Silver	Percentage *Copper*	*Zinc*	*Cadmium*	*Grade**	*Color*	*Melting Point (°F.) (Approx.)*
10	52	38	—	1	Yellow	820
20	45	35	—	2	Yellow	775
20	45	30	5	3	Yellow	775
45	30	25	—	4	Almost White	675
50	34	16	—	5	" "	695
50	15.5	16.5	18	Easy-Flo	———	627
65	20	15	—	6	White	695
70	20	10	—	7	White	725
80	16	4	—	8	White	740

* Numbers refer to ASTM grades.

BATTLE STATIONS
-on the double

There goes the air raid alarm. And here they come, the fighter pilots . . . scrambling madly for their waiting planes. You'd hurry too if you were in their shoes, because time grows mighty important right then. Only a split second can make all the difference between getting upstairs in time, and maybe not getting off at all.

Speed is vital, too, in the building of all the tools and weapons our fighting men need. Speed, that is, consistent with good workmanship.

The young lady pictured at left is helping to send electrical instruments to battle stations faster, and in greater volume, than ever before. Hers is the delicate task of fastening the top hair spring to the armature. Note how the specially designed jigs not only speed her work, but insure accurate, precise assembly.

This single operation, all by itself, can not materially reduce the time required to build an instrument. It does serve, however, as a small indication of the many new ideas and refinements that have enabled Simpson to make such great strides in instrument manufacture.

In all Simpson instruments and testing equipment you will find a basically superior type of movement which required a slow and costly method of construction only a few years ago. Today, in the Simpson plant, this greater accuracy and stamina is a matter of mass production.

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an extension bit. The hole from the inner wall to the outer wall should always slant downward so that moisture gathering on the wire will not run along the lead-in into the room.

Brazing

Occasionally, in radio repair work, it is necessary to join metals so that the resulting joint is stronger than would be obtained by ordinary soldering methods. For such operations on copper, brass, German silver, and similar metals, brazing is often used. In brazing, a hard solder consisting principally of copper and zinc is used. The flux required is calcined borax or boracic acid. Because of the high melting point of hard solders, a soldering iron cannot be used. Instead, the joint is heated to red heat with a blow-torch or its equivalent.

Work to be brazed must first be cleaned, then fastened together mechanically where practicable. The copper-zinc alloy chosen for brazing should have a fusing point as closely as possible to that of the metals to be joined. By so doing, the brazed joint will have the greatest possible strength. The fusing point of the solder is dependent upon the proportion of zinc. The greater the percentage of zinc, the lower the fusing point. When brazing steel, copper or iron, it should be remembered that such metals have a higher melting point than brass and consequently a brazing solder with less zinc should be used. A list of brazing solders is given in *Table I*. For general work, the SAE specification brazing solder is good to use. This consists of copper, about 50%; lead, 0.5% (max.); zinc, remainer. This melts at about 1600°F. The cleaning before brazing is done by grinding or filing, although a chemical cleanser composed of a solution of one-third nitric acid and two-thirds sulphuric acid may be employed. The parts are dipped into this solution before brazing.

Silver Soldering

Another form of hard soldering is "silver soldering." Silver solder is generally employed by jewelers on precious metals—also on other small, delicate jobs where a strong connection is required. Its application is not limited to precious metals; it may be used on iron and steel as well. It is particularly adaptable in radio to the repair of small, broken parts which are under considerable mechanical strain. While silver soldering is not as strong as brazing because of its lower melting point, it is considerably stronger than the usual lead-tin solders often employed. It can be used in the repair of drive cables, cams, and other small components of radios. The same flux, borax, is used as for brazing. A list of suitable silver solders is shown in *Table II*.

TABLE III

LOW MELTING POINT ALLOYS

	Percentage			*Melting Point*
Bismuth	*Lead*	*Tin*	*Cadmium*	*(°F.)*
50	25	12.5	12.5	149
38.4	30.8	15.4	15.4	160
50	34.5	9.3	6.2	171
50	25	25	—	187
50	—	25	25	203
25	50	25	—	300

Other Soldering

There are other cases in radio work where none of the hard or soft solders may be used because the melting temperature is too high. Such a condition is met when it is necessary to repair a metal connection on a polystyrene form. The melting point of polystyrene is much lower than any of the standard solders, therefore, unless it is possible to make the repair and allow it to cool before placing on the form, trouble results. For such applications, special low-temperature alloys are available. The low melting point is obtained by using a high percentage of bismuth, together with cadmium, tin, and lead. Some representative low-temperature alloys are tabulated in *Table III*. These compare favorably with Wood's metal, which melts at 140-160 degrees F. Polystyrene cements are also available.

Often it is necessary to solder aluminum parts, or to solder some other metal to an aluminum chassis. For this purpose a standard aluminum solder, composed of 75.5 parts of tin, 18 parts of zinc, and 2.5 parts of aluminum, (all by weight), may be used without any flux. The parts to be joined should first be heated slightly. It is also possible to use a mixture of 80% tin and 20% zinc, with stearic acid as a flux.

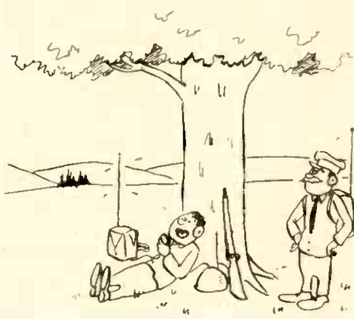
Cementing

There are occasions when it is necessary to repair parts which have become cracked and which cannot be soldered. When it is necessary to cement glass dials to metal panels, a paste mixture of glycerin and litharge will serve the purpose.

For cementing loudspeaker cones household cement can be used successfully; also for a wide variety of applications where parts other than metal are involved. For rubber and synthetic rubber components, a rubber or neoprene type cement is recommended. This may be used for fastening rubber grommets to chassis, etc. In some instances, the use of cement will save an awkward or difficult mechanical job. For example, in mounting a socket on rubber to overcome microphonic tendencies, the rubber may be cemented directly to the chassis and also to the socket being suspended. If this job were done mechanically, it would be necessary to isolate the screw and nut from the chassis so as not to interfere with the vibration absorption obtained with the floating rubber mount.

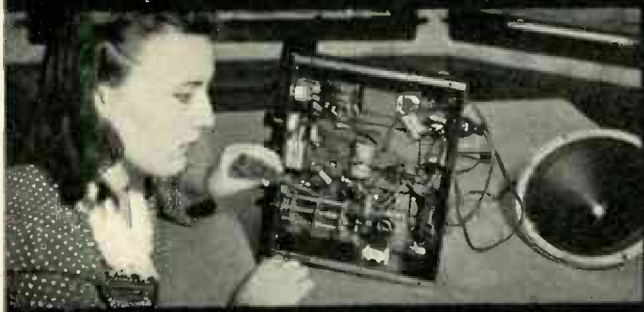
Care in Use of Pliers

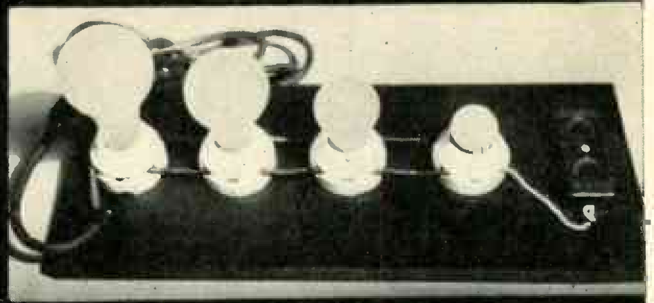
In handling small parts to be soldered or brazed, long-nozed pliers are most convenient to use. It should be kept in mind that these pliers must never be used for heavy work. Often we see such pliers used in an attempt to loosen large nuts which are difficult to get at. This sort of work places a heavy strain on the points of the pliers—so much so that even the best may become bent or broken. When these pliers are in perfect condition it should be possible to hold a hair between the points—they will not stay this way if misused. We want to emphasize this point because good tools are now so valuable and so hard to replace.



"I am now fighting my way through a thickly wooded forest, puff, puff, will report new position later!"

SERVICING . . . . . . WITH LAMPS





by F. L. Sprayberry

PART 2

This is the second of a series of articles in which Mr. Sprayberry describes how sets may be checked with lamps when no regular test equipment is available.

The vital parts of any power unit filter circuit are the *filter condensers*, *choke coils* or *speaker field*, and the resistor *voltage divider*. In *Fig. 2*, these are C51 and C52 for condensers, the speaker field coil as a choke, and R28, R29, R27, and R26 for the voltage divider (neglecting for the moment the shunt path for current to the other tubes in the receiver). Any other a.c. power unit circuits are to be regarded in like manner, because they would include these essential elements. Therefore, the tests about to be described are applicable to all other receivers which are similarly arranged.

With reference to C53 (40 mfd.) in *Fig. 2*, this too, may be regarded as a filter condenser although its prime purpose is to bypass or filter the a.c. ripple across R26 and R27 because these are bias resistors for the push-pull and a.*f*. tubes.

To avoid confusion due to possible defects in other parts of the receiver, disconnect the B+ feed line at the output of the power unit. In this case (see *Fig. 2*), open the link circuit and disconnect all leads at C52 except the one from the speaker field.

To begin the individual tests of parts in the power unit circuit, use a 10-watt lamp in your test circuit, place the rectifier tube in its socket and turn on the receiver switch. Now, take an insulated-handle screwdriver or other insulated-handle metal tool, or a short length of insulated wire, and "short" (directly connect) the positive terminal of C51 to ground. If this condenser is in good condition, there will be a large spark upon making the short-circuit and the 10-watt lamp will increase in brilliance to its limit. On the other hand, if there is no spark and if the lamp does not increase in brilliance, condenser C51 is definitely shorted and should be replaced.

To check C52 or other condensers similarly connected in other receivers, proceed as before, shorting from the positive terminal of the condenser to ground. As before, for normal conditions, there should be a spark upon making the short-circuit and the 10-watt lamp should increase in brilliance.

Testing at C52 also at the same time checks the condition of the speaker field winding. If you get a satisfactory test for normal conditions as described, you may assume the speaker field coil (or choke coils if any are used) to be in good condition.

If it should happen that you *get no spark* and the *lamp brilliance does not increase* when making the short at C52, then the speaker field or choke coil is open and must be replaced. If the lamp is already brightly lighted and shorting at C52 does not increase its brilliance, then C52 itself is shorted. But you must be careful in making this analysis. There are various degrees of condenser short-circuit. It may be complete (high leakage), with little d.c. resistance (so-called "low-resistance short", or even a direct short-circuit), or it may only be partial (low leakage), with considerable d.c. resistance (so-called high-resistance short). With a (full) short-circuit at C52 considerable current may already be flowing. As a result, a short at C52 with a metal tool may not increase the current flow any (therefore, no increase in lamp brilliance). Thus you see there is a possible point for confusion.

You can double-check here to determine the absolute condition of condenser C52. If you have any reason to suspect it, unsolder the positive (+) lead of C52. Then short-circuit the free speaker field terminal to ground. If this time you get a large spark and the lamp increases in brilliance, it definitely shows that C52 is at fault because before with C52 in the circuit, the increase in lamp brilliance might not have been so evident. If the B+ feed line to the other circuits had not been disconnected at the beginning it is possible there may have been a short or heavy load of some kind on beyond C52 in one or more of the B+ circuits. If such a short had little or no resistance, it would draw enough current to make it appear that C52 was at fault. This possibility can be checked by reconnecting C52 and the lead or leads which feed the B+ circuits one at a time. It makes no difference whether you reconnect C52 or the B+ feed line first. If everything is normal, with C52 reconnected first, then the B+ circuits may be at fault (reference to small bypass condensers for the B+ circuits will be made again further on). If the B+ feed line is reconnected first and results are normal, then C52 is at fault. By such a process of elimination, the defect as you can see, may be narrowed to one part. Also, such tests can be done surprisingly fast, as you will learn after using this test method a few times.

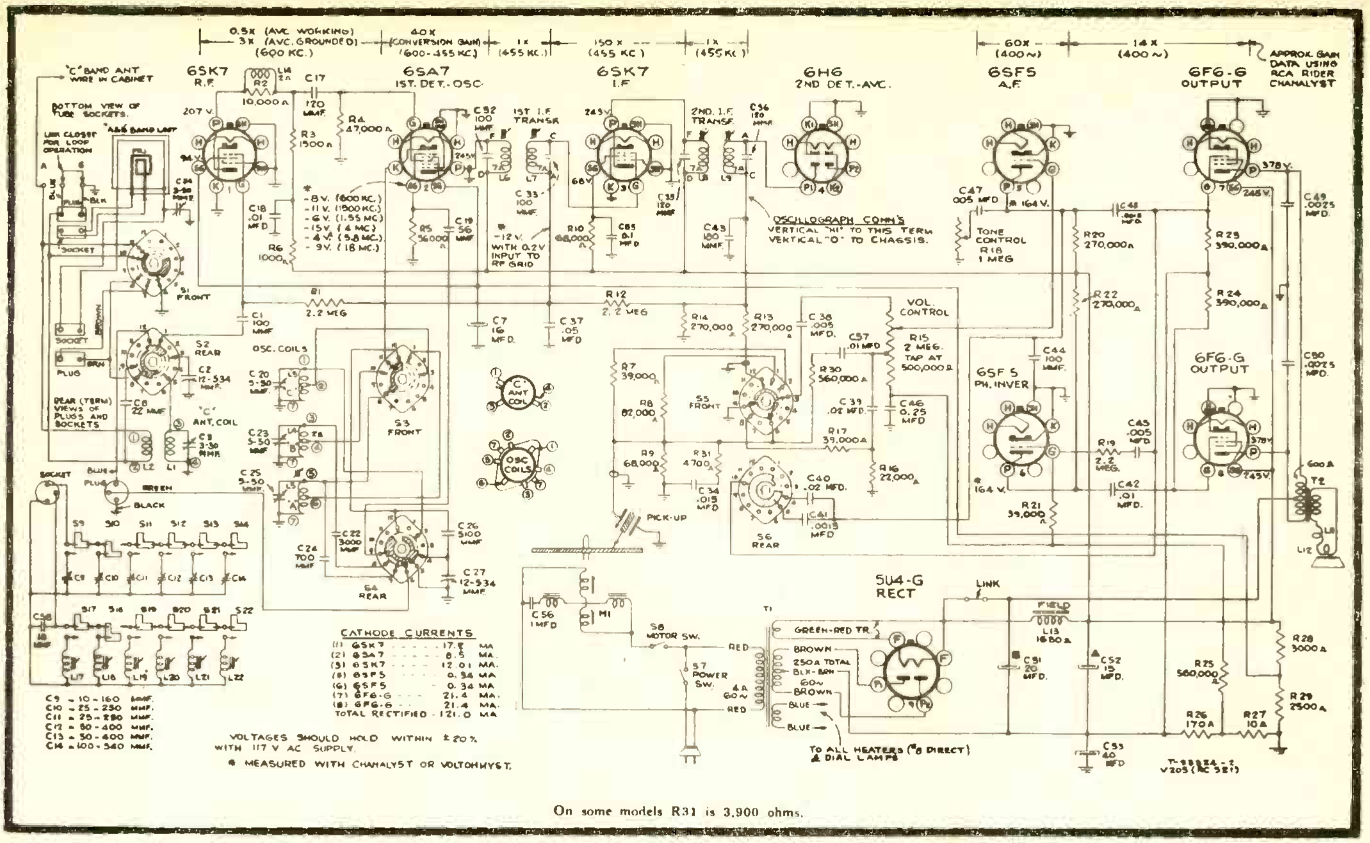


Fig. 2. Representative circuit of a modern multi-band phono-radio receiver having pushbutton tuning, loop antenna, and other features. Such a receiver can be tested without meters, by following the author's step-by-step procedure.

Checking Tube Circuits

So far, we have tested the complete power unit up to the voltage divider. As we made progress, we eliminated the possibility of defects as we went along.

We are now ready to check the condition of the individual tube circuits. As we make progress through the various stages and add more tubes it will be necessary to increase the power rating of the test lamps (in the test circuit of *Fig. 1A*) because as more tubes are added to the circuit, more and more power is consumed.

At this point in the testing procedure, it is not necessary to check each of the individual resistors making up the voltage divider unless you have conclusive evidence that one or more of these is at fault. By checking conditions at the tube sockets you will at the same time check the voltage divider. Another point to remember is that, as you get further and further away from the power unit and include more and more resistance in your test circuit, the shorting of a part to ground has less and less effect on the test lamps. This is because the *added resistance* further controls the amount of current that can flow, and therefore, the effect on the lamps is not so evident. Even so, by careful observation it is possible to go through an entire set and determine the condition of each part by direct and indirect tests.

The next step in our testing procedure is made on the a.f. output stage—this stage may employ one or two tubes—in either case the same procedure is followed.

Place a 25- to 50-watt lamp in your test circuit, and for *Fig. 2*, place the two 6F6G tubes in their respective sockets. Next turn on the receiver power switch. The test lamp normally should glow at about one-half brilliance. If the lamp is already to nearly full brilliance, use a lamp with a higher power rating in your test circuit. If, on the other hand, it too lights up to full brilliance, then there is an overload in the output circuit and by the process of elimination you will be able to find the defect.

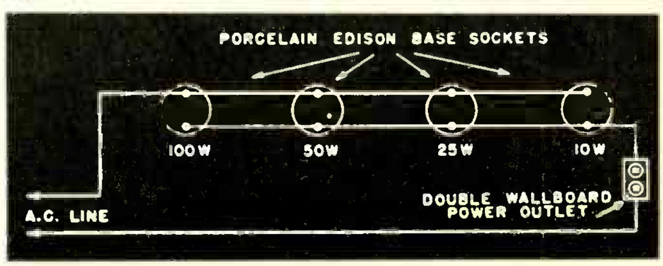
Our object is to determine the relative working condition of each part associated with this stage. *Fig. 3* shows the stage we are concerned with—the rest of the circuit being omitted.

First we want to know if plate voltage is applied to the plates of these tubes. To prove or disprove this, *momentarily* short-circuit each plate terminal to the metal chassis (ground) with an insulated-handle metal screwdriver. You should get a large spark when making this "short", and the test lamp should increase in brilliance. (Note that a lamp rated no higher than 50 watts is specified in the lamp bank when this test, which places a high load on the power supply system, is made).

Let us suppose you don't get this normal effect. With no spark and no increase in lamp brilliance, it means no voltage is reaching the plates of the tubes. Knowing our power unit is normal, it follows that the defect must be between the power unit output and the plates of the push-pull tubes. This circuit consists of the wires from the plates of the tubes to the speaker plug, through the speaker plug socket, through the primary of the output transformer and on to the power supply. It is not likely the circuit wires themselves will be open although the soldered joints may be poorly made.

The next step then is to check the condition of these by visual inspection. The defect is more likely to be at the speaker plug, its socket or in the speaker output transformer.

Fig. 1A. Multi-lamp circuit to be used when trouble shooting without meters.



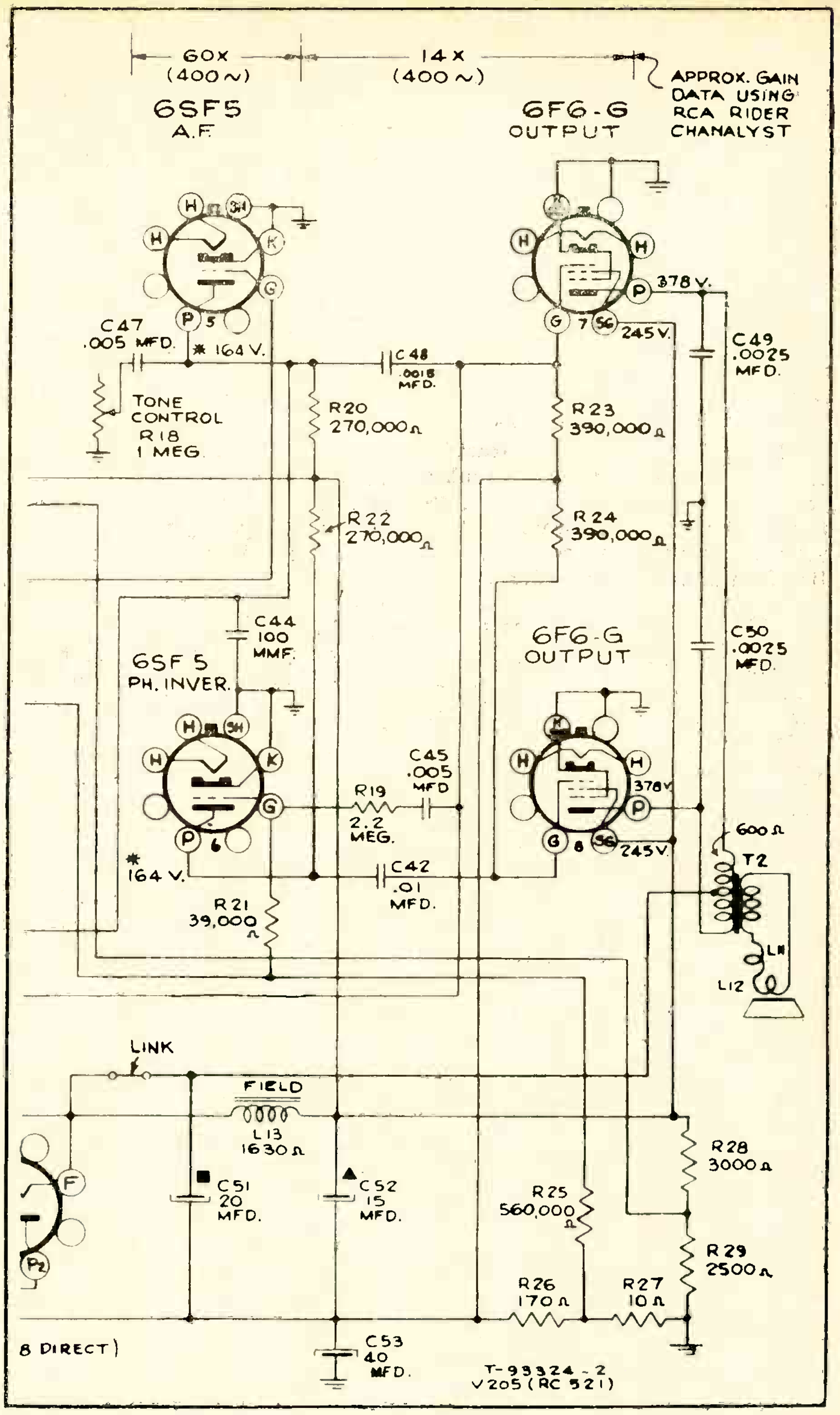


Fig. 3. The output section of RCA Model V-205. The complete circuit is given as Fig. 2.

Therefore, you should see that the speaker plug makes firm contact to the speaker plug socket and that all soldered connections are in good electrical condition. If there is any doubt in your mind about the soldered connections, remelt the solder with a hot soldering iron (adding more solder if necessary). Incidentally, this same observation applies to any other soldered connections in the receiver.

With the foregoing checks made, all that remains as a possible source of trouble is the primary of the output transformer. This may be open-circuited, preventing voltage from reaching the plates of the output tubes. It may be "open" in only one section—that is, in one or the other sections from the center-tap—or it may be open in both sections. There are several ways to check this. The simplest way to do it is to unsolder all 3 connections from the output transformer and temporarily connect these 3 wires together. If, on doing this and *momentarily* shorting at the plate terminals of the output tubes to ground, you get a normal reaction (a spark upon making the contact and an increase in the test lamp brilliance), it proves the primary of the output transformer is open, and therefore, needs replacing.

More Output-Circuit Checks

While you are checking the output stage you can also check the condition of the complete output transformer and the speaker voice coil circuit. To do this, you simply observe whether or not there is a loud click emitted by the speaker when you short from the plates of the output tubes to ground. Such a click indicates in a relative way that the primary and secondary of the output stage passes a signal and that the voice coil circuit is complete. If you have previously tested the power unit as directed, you will have already established that the speaker field itself is functioning properly.

Previously, we mentioned in connection with testing C52, that it was perfectly possible for a short to exist along the B+ circuit feeding the other tubes and that, if this short-circuit had little resistance, the effect might be to make it appear that C52 was shorted. We pointed out also that the way to check this was to disconnect the B+ feed line, check the condenser as directed and then from the effects exhibited, determine where the defect existed — either along the B+ circuit or in condenser C52 itself. We will now take up the testing of the B+ feed line—*but it is important for you to remember the general principles because these principles can be applied to any set and they will be conclusive.*

In any set the B+ feed line is from the output of the power unit through all elements to ground, and back to B— or to the center-tap on the high-voltage winding of the power transformer.

Our tests must include all units between these extreme points (B+ and B—). On our previous test for plate voltage on the two 6F6G output tubes the tubes were supposed to be in their sockets. The purpose of this was to place a load on the power unit and to enable us to get a relative check on the speaker circuit. Normally this would be all right but if it should happen that C49 or C50 in *Fig. 2* (or any other similarly connected condenser) were shorted (a likely type of defect), or the B+ circuit was grounded in some other way, then the test by shorting from plate to ground at the tube sockets *would not be conclusive*. Thus, if you make a test like this and do not get the proper effects (a spark on making the short-circuit and an increase in test lamp brilliance), a more complete isolation test must be made of the entire B+ feed line.

Again, we will refer to the first test described for C52. By disconnecting the B+ feed line, you will remember it was possible to determine whether the defect was in the condenser or further along the B+ circuit. Let us suppose it was proven that with the B+ feed line disconnected, testing effects were normal for the power unit. It then follows that the defect must be along the B+ circuit. To find the exact location of the defect, remove all tubes from the receiver except the rectifier. Use a 10- to 25-watt lamp in your test circuit and reconnect the B+ feed line to the rectifier output.

High-Voltage D.C. Tests

In testing through the receiver it is much more convenient to carry our tests up to and including the plate terminals of the tube sockets (the high-voltage d.c. circuits). Then with this completed we can continue our tests from the cathode terminals of the tube sockets (the low-voltage d.c. circuits) back to the center-tap of the power transformer.

To illustrate these particular d.c. tests as clearly as possible, the high-voltage d.c. distributing circuits of *Fig. 2* have been included except the plate loads for the various tubes However, these will be automatically tested as we proceed. All other receivers can be reduced to these bare essentials. It will not be necessary for you to lay out the circuit of the receiver you are working on as we have done in *Fig. 4*—all you will need is an original schematic diagram of the receiver and *even this is not necessary if you will remember the basic principles of this method of testing.*

Study *Fig. 4* in detail for a few minutes and compare it with the complete circuit of *Fig. 2*. Note carefully that although the appearance of *Fig. 4* is different from that presented in *Fig. 2*, yet these two high-voltage d.c. distributing circuits are in exact electrical agreement. Basically you will see that *Fig. 4* consists of resistors and condensers. Since, for the moment, we are hunting for high-voltage d.c. defects you should immediately remember that for d.c., resistors will normally pass current —if they don't, they are open, and therefore, defective. For condensers, we have the opposite effect—normally they will not pass d.c., and if they do (normal current flow for electrolytics excepted), they are shorted and need replacing.

With these general observations we are now ready to continue with our testing.

With all tubes removed except the rectifier, the only load on the power unit will be (or should be) the bleeder current through the voltage divider and the small leakage current through the electrolytic condensers. This is not enough load to cause your test lamp to burn brightly. Therefore, under these conditions, if it does burn brightly, you may be sure it is due to a shorted filter or bypass condenser or grounded B+ circuit. On the other hand, the dim test lamp might mean that one or more vital resistors in the power unit are open. Therefore, we cannot afford to assume or guess about conditions—we must *prove* them as we go along with our testing.

In testing such circuits as *Fig. 4*, it will be convenient to divide the circuit in sections. The logical place to do this in *Fig. 4* is to open the circuit between R6 and R20 indicated by X in the diagram. The action of the test lamp will indicate in a general way what you will need to look for. If the test lamp burns brightly the chances are the defect is due to a shorted condenser. To check on this, all you have to do is disconnect one condenser at a time but you *must* keep in mind some basic principles.

Suppose you have separated the B+ circuit in *Fig. 4* at X. There are only two condensers in this section

(Continued on page 36)

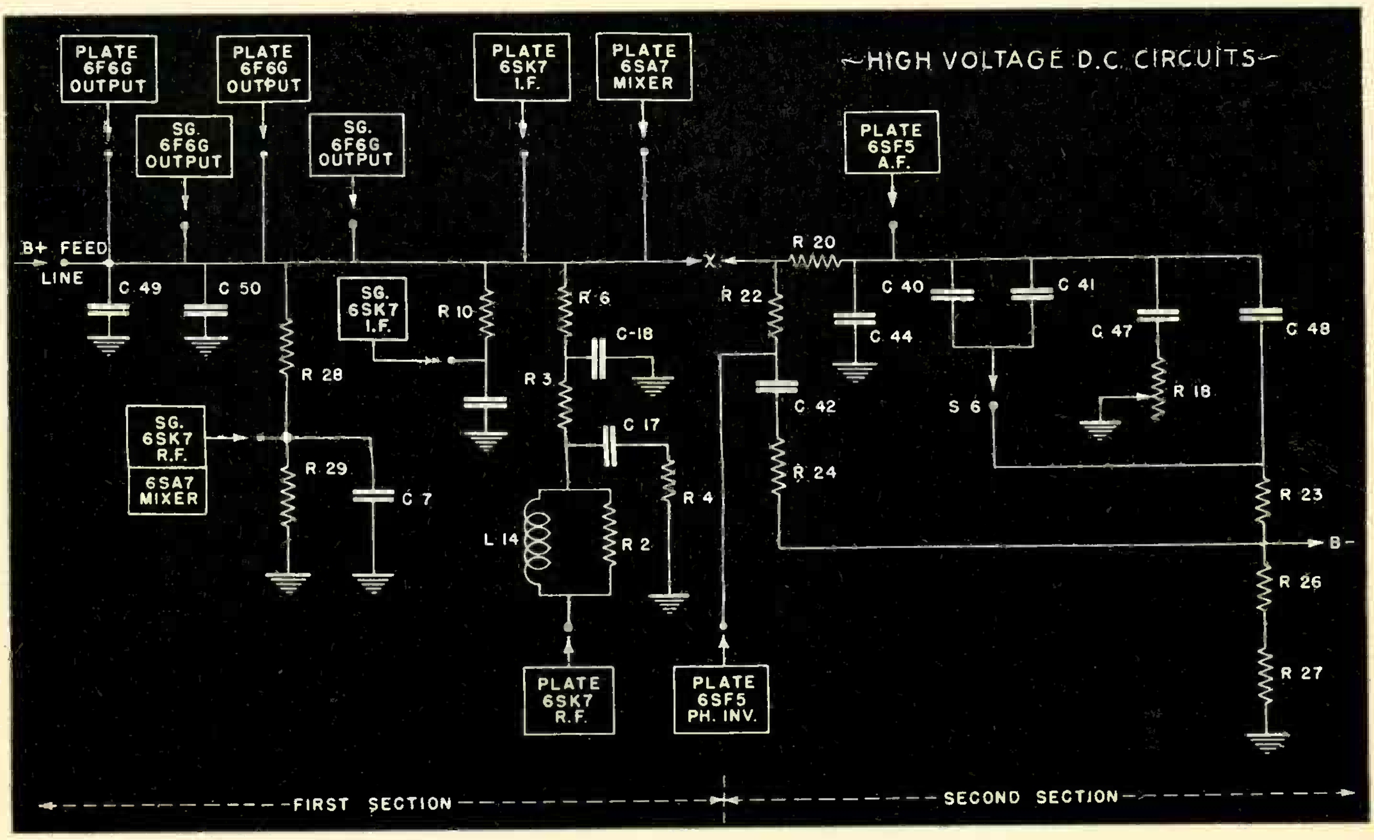


Fig. 4. The high voltage section of RCA Model V-205 showing the tubes, condensers, and resistors in simplified form of Fig. 2.

BASICS OF SOUND

by Sidney Harman PART 3

★ We intend, in this article, to present a simplified analysis of the dynamic action of a power amplifier with inverse feedback; and to accomplish this presentation through the use of simplified mathematics.

A review of tube manual specifications will prove extremely helpful in the understanding of this analysis. It will be remembered, for example, that the load resistance (R_L) is:

$$R_L = E_{max} - E_{min}/I_{max} - I_{min}$$

Harmonic distortion in the average beam power tetrode is 10% second harmonic, and 3% third harmonic for Class A operation. (5% second harmonic distortion is considered the maximum distortion which can pass the human ear without detection although 10% second harmonic distortion with little or no third or fifth harmonic distortion can be generally detected only by a trained ear. Third harmonic distortion is most annoying and other higher odd harmonics cause a more disagreeable effect than do higher even harmonics.) Most commercial amplifier manufacturers specify total harmonic distortion, and it is of value to know that this total is not an arithmetic addition of the various harmonics but is more nearly a root mean squared (RMS) derivation. The formula for total harmonic distortion, then, is:

$$D = \sqrt{H_2^2 + H_3^2 + H_4^2 + H_5^2} \text{ etc.}$$

where D is the total harmonic distortion, H_2^2 is the second harmonic distortion squared, etc.

The use of total harmonic distortion as a specification is generally frowned upon, however, as not a true indication, and it is always best to know the specific value of each harmonic.

The effects of harmonic distortion due to higher odd harmonics are called (a) Cross Modulation, and (b) Combination tones.

Cross Modulation

Cross Modulation is the effect that two signals have upon each other's amplitude in the output of a distorted amplifier when the inputs are constant. Thus an increase in the amplitude of one signal may result in a decrease in the amplitude of the other dependent upon the phase relationship which exists. To clarify this phenomenon, consider the result which sometimes occurs while listening to two instruments, perhaps a string instrument with an organ accompaniment. The amplitude of the string instrument sound will vary in accordance with the more powerful bass accompaniment.

Combination Tones

Combination Tones is a term which represents the beats between the frequencies of different fundamentals and harmonics. The output of an amplifier which produces harmonic distortion will consist of the "input frequencies" and the beats of those frequencies. In other words, the result will consist of the original frequencies plus various combinations—sums and differences of the fundamentals and their harmonics. Inputs of 100 cycles and 200 cycles will result in 100, 150, 200, 225, 300, and many additional. The actual number and strength of these combination tones increases as harmonic distortion increases. It can be appreciated how under normal conditions these combination tones will cause intense irritation to a listener.

It is interesting to note that the principle of combination tones has been employed in some midget radio loudspeaker circuits to provide a "pseudo bass" which the speaker and receiver circuit could not normally reproduce. The human ear will supply the missing fundamental if enough of the harmonics are present, and therefore, through amplification of the harmonics of the frequencies around the bass resonant frequencies, a seeming bass response is provided. (See *"Speech and Hearing,"* Harvey Fletcher and Shepard's papers).

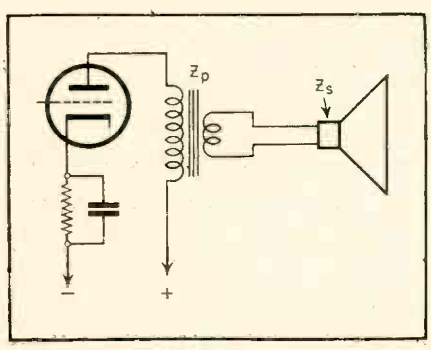


Fig. 1. Typical output circuit.

It is the function of Negative Feedback (1) to reduce harmonic distortion, (2) to provide greater stability, and (3) to improve frequency response. How these ends are achieved will now be analyzed.

The familiar 6L6 beam power tube has 10% second harmonic distortion with a 6000-ohm resistive load facing the tube. This distortion is considered too high, for it will be remembered that 5% is the maximum acceptable second harmonic distortion for a well designed amplifier.

The distortion of any tube is calculated with R, a constant resistance, as the load. It will be remembered that in Part 2 of this series (August 1943 RADIO SERVICE-DEALER), the formula $Z_P = N^2 Z_S$ was established to determine the primary or reflected impedance (Z_P) of the output transformer. It is this value (Z_P) which actually loads the output tube (see *Fig. 1*) and in practice it does not represent a fixed load on the tube since the value of the secondary load (Z_S) varies with the bass resonant frequency of the speaker which is used as that load. *Figure 2* is voice coil impedance curve of a popular cone type speaker.

It will be seen that at 1000 cycles the voice coil impedance is approximately eight ohms, and catalogs will therefore refer to such a speaker as an 8-ohm voice coil unit. The voice coil impedance is resonant at 100 cycles and it is evident that the secondary load on the output transformer will vary from 8 to as high as 40 ohms. This variation results in a varying value for Z_P, therefore in a varying load on the output tube and as a result in varied gains and increased harmonic and frequency distortion when the amplifier is driven to full output. The need for inverse feedback is therefore apparent.

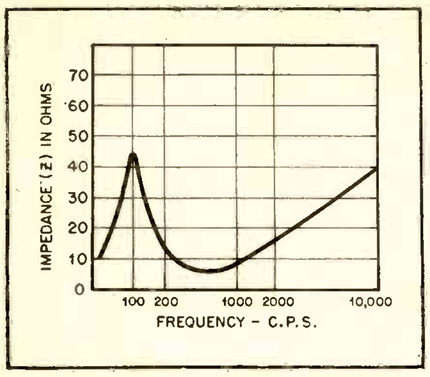


Fig. 2. Voice coil impedance curve of a popular cone type speaker.

Inverse Feedback

By glancing at *Fig. 3*, you will see that R_A and R_F form a voltage divider, $R_F/R_A + R_F$ across the output load and this voltage divider feeds back a portion of the output voltage which is equal to the full output voltage multiplied by the fraction $R_F/R_A + R_F$.

C_B is only a blocking condenser for d.c., and must be of high quality if the feedback is to be stable. The output voltage (E) of a tube is 180° out of phase with the input and through inverse feedback a force is applied to the input of the tube which is theoretically opposite in phase to the input voltage.

This is the fundamental principle of inverse or negative feedback, but before analyzing its effect upon frequency response and distortion it is recommended that the reader review the causes and nature of distortion:

(a) distortion due to incorrect grid bias
(b) distortion due to mismatching of impedance
(c) distortion due to overloading

The speaker in most common use is the dynamic type. Actually, this unit represents a quite complicated system, see *Fig. 4*.

Although most output formulae ($Z_P = N^2 Z_S$) look upon Z_S as a constant, it is not technically correct to do so. Reference to *Fig. 4* will clarify this thought, for although a highly simplified picturization of the complex network which is the loudspeaker, it does indicate why the loudspeaker load is not constant and why it affects the frequency response of tetrodes and pentodes and not of triodes.

When the mass of the vibrating system becomes resonant with the compliance (springiness) of the speaker cone, there is a maximum radiated power and the physical impedance to motion of the voice coil is very low. This is, of course, the natural result of the mechanical parallel resonant circuit, but the motional impedance of the voice coil is quite high. This motional impedance is the electrical impedance of the voice coil when it is moving and it is equal to E/I where E is the counter EMF induced in the voice coil and I is the current causing the vibrations of the speaker cone.

Increasing the load facing a triode decreases the current in the secondary of the output transformer, and as a result the loudspeaker peaks are effectively suppressed or damped.

The plate impedance, in *Fig. 5*, of a typical triode is 2000 ohms, and a transformer is selected so that when loaded with a 6-ohm voice coil, the reflected impedance is 2000 ohms. Assume that at resonance the voice coil impedance becomes 20 ohms and Z_P = 8000 ohms instead of 2000 ohms. At 8000 ohms load the power is decreased and the current flowing in the secondary of the output transformer is therefore decreased and the peak is damped since the current causing the speaker vibrations is reduced.

In a pentode the effective plate impedance (*R*) is much higher (possibly 20,000 ohms) than the transformer load impedance (possibly 3000 ohms for a 6-ohm voice coil) and the counter EMF merely increases the voltage drop across the speaker input without changing the current and resulting in an increased resonant peak.

Constant Voltage Inverse Feedback

Inverse feedback (constant voltage type) damps out these peaks since it prevents variations in gain in the tube with frequency and makes the tube act like a triode. In other words, the application of inverse feedback reduces the effective plate impedance of the pentode to a point where the pentode behaves like a triode. (This is also true of beam tetrodes.) The actual plate resistance is not changed by feedback, but the effect is the same as if it were.

In *Fig. 3*, note that the resistors R_A and R_F form a voltage divider which produces a feedback voltage. Assume that R_A = 10,000 ohms and that R_F = 90,000 ohms. Assume further, that the gain of the amplifier without feedback is 50, (the ratio of the voltage output over the voltage input).

The feedback factor is

$$\frac{R_A + R_F}{R_F} = \frac{100,000}{10,000} = \frac{10}{1}.$$

This feedback factor, usually referred to as β(Beta), is negative in value and represents the percentage of the output voltage which is fed back.

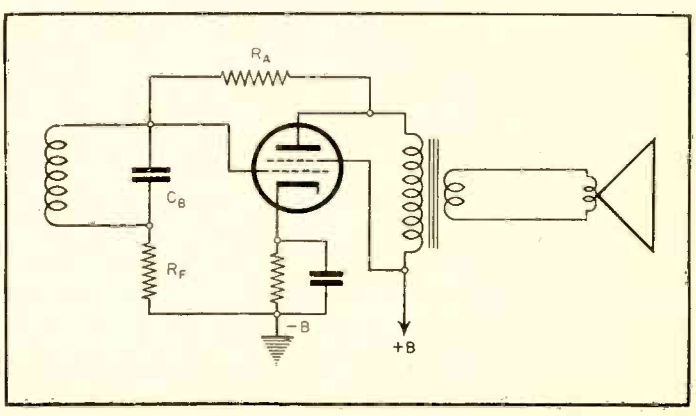
The formula for the gain of an amplifier with feedback is: Gain (with feedback) = Gain without feedback/1 — (feedback factor × gain without feedback) or, $M' = M/1 - \beta M$. In the example referred to, this would appear as: $M' = 50/1-(-.1 \times 50) = 50/1-(-5) = 50/6 = 8.3$.

Without feedback, a signal of 1 volt at 500 cycles would produce an output signal of 50 volts if the gain of the amplifier at that frequency were 50. If at 2000 cycles a signal input of 1 volt produces a signal output of 100 volts in the same amplifier, the amplifier is frequency distorted. The ratio of the output is 100:50 or 2 to 1 without feedback.

With feedback at 500 cycles, an input signal of 6 volts (5 volts to overcome the feedback voltage) is required to produce 50 volts across the primary of the output transformer, for the actual voltage feedback (βE or .1 × 50) is 5 volts. Another way to look at this condition is—since the gain of the amplifier with the feedback is 8.3 (as determined above) a signal input of 6 volts is required to deliver a signal output of 50 volts.

At 2000 cycles with inverse feedback, 5.5 volts input is required to produce the 50 volts across the primary of the output transformer.

Fig 3. Resistors R_A and R_F form a voltage divider regulating feedback.



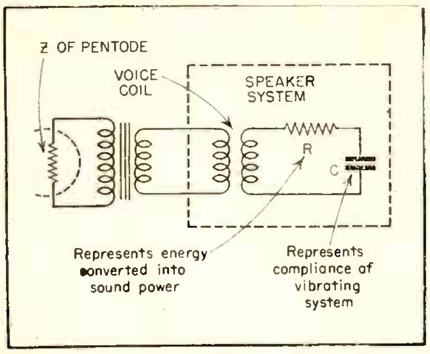


Fig. 4. Most commonly used circuit employs dynamic speaker.

Since 1 volt input will produce 100 volts output, .5 volts input will produce 50 volts output without feedback, and with feedback the additional 5 volts input is required to compensate for the feedback voltage. This can be seen also in the following manner: The gain of the amplifier with feedback at 2000 cycles is $100/1—(—.1 \times 100) = 9.1$ (approx.) In order to obtain an output voltage of 50 volts, such an amplifier would require an input signal of 5.5 volts ($5.5 \times 9.1 = 50$).

Compare the gain ratios of the amplifier at the specified frequencies with feedback: $9.1/8.3 = 1.1:1$. Now compare this ratio with the ratio of 2:1 which exists without feedback, and it will be apparent how inverse feedback serves to reduce frequency distortion.

Harmonic Distortion

Similar reasoning can be applied to harmonic distortion. Let D = the distortion voltage in the primary of the output transformer without feedback, and let D′ = the distortion voltage in the primary of the output transformer with inverse feedback at the same output level. The distortion voltage fed back to the input is $—\beta D'$ (the product of the feedback ratio and the distortion voltage output with feedback). This voltage is of different frequency than the input voltage and as a result there is no cancellation. The output voltage due to the voltage fed back is equal to the product of the voltage fed back and the gain of the amplifier ($—\beta D'M$). This voltage is out of phase with the distortion voltage (D) which appears without feedback and the resultant distortion voltage is $D' = D + \beta D'$ or $D = D' — \beta D'M$ or $D = D'(1—\beta M)$ or $D' = D/1—\beta M$. Since β, the feedback ratio is negative, the value of $1—\beta M$ is greater than unity and D′ is smaller than D.

Assume a harmonic distortion of 10% in the example used. Of the 50 volts output, 5 volts are distortion. The new distortion with inverse feedback would be: $5/1—(—.1 \times 50) = 5/6 = .83$ volts. Compare the distortion percentage without feedback ($5/50 = 10\%$) to the distortion percentage with feedback ($.83/50 = 1.6\%$), and the advantages of inverse feedback for the reduction of harmonic distortion is obvious.

The above treatment is not completely accurate from an engineering point of view, but for practical design purposes, it is perfectly satisfactory and eliminates a good deal of complicated mathematics which would only serve to confuse the basic understanding which this article attempts to achieve.

The one condition which must be maintained is that R_F and R_A must not load the plate impedance of the output tube. The impedance of C_F is assumed to be negligible at audio frequencies.

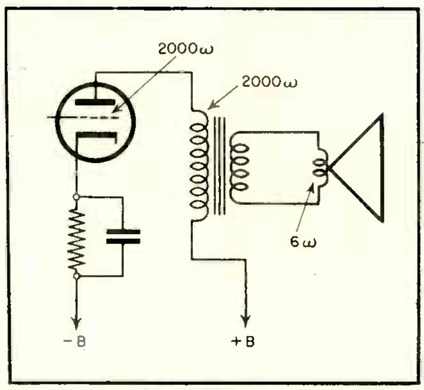


Fig. 5. Method by which speaker peaks are suppressed.

Plate Impedance

It will be remembered that earlier in the article, the effect of inverse feedback on the plate impedance of a pentode or beam tetrode was outlined.

Let us apply the same problem, employed in examining the effects of constant voltage inverse feedback on frequency response and distortion, to the question of plate impedance.

The formula is: New Plate Impedance (effective) = Old Plate Impedance (per tube manual)/1—(feedback factor × amplification factor of tube per tube manual), or, $R_O = R_P/1—\beta M$. In our problem this would become: $R_O = 20{,}000/1—(—.1 \times 50) = 20{,}000/1—(—5) = 20{,}000/6 = 3333+$. This low impedance is effectively equivalent to the plate impedance of a triode, and the damping action described herein for a triode is thus achieved.

The above discussion has been concerned with what is known as *Constant Voltage Inverse Feedback*, and continuous reference has been made to this title.

Constant Current Inverse Feedback

A second type of inverse feedback is known as *Constant Current Inverse Feedback (See Fig. 6)*.

Bias for the control grid is obtained from the cathode resistor *R* which is not by-passed (note dotted by-pass condenser). Thus, when at any frequency a signal voltage is impressed upon the control grid, current flow through the plate circuit is increased and current increases are not stored because of the absence of a by-pass condenser across the bias resistor. As a result, there is a greater drop across the bias resistor and the grid becomes more negatively biased.

The additional voltage drop across the bias resistor (*R*) is theoretically 180° out of phase with the original bias voltage. Assume a distorted wave shape *Fig. 7(A)* without constant current feedback.

The wave form of the voltage fed back out of phase with the original voltage is shown in *Fig. 7(B)*.

These wave forms can be shown as in *Fig. 7(C)* and the resultant of the two is as seen in *Fig. 7(D)*.

This wave form analysis is equally applicable to the previous discussion of constant voltage inverse feedback.

This type of feedback is not generally employed unless voltage inverse feedback is also used, since constant current feedback in contrast to voltage feedback results in an increase in the effective internal resistance of the pentode or beam tetrode. As a result, it does not cause a reduction in frequency dis-

(Continued on page 34)

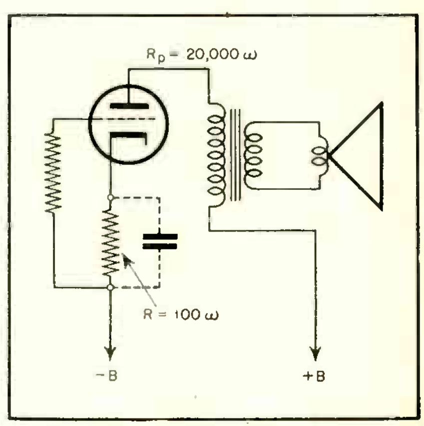
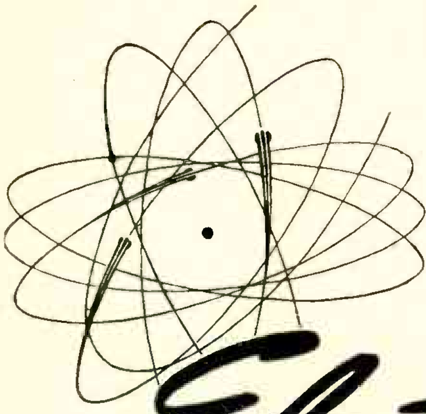


Fig. 6. Circuit for Constant Current Inverse Feedback. Resultant wave forms are shown in Figs. 6A-6B-6C-6D.



Electronics

by Paul R. Heyl, Ph. D.

Part 2. "Electrons at Work"

In this, the second article of a series on Electronics, Dr. Heyl describes how electrons can be "put to work".

★ In our last lecture we reviewed what modern theory had done (or tried to do) in the way of shaping our concept of electrons, and we saw that the net result was to leave us perhaps a little bewildered. When electrons were first discovered, some half century ago, it was natural to visualize them as tiny particles of matter carrying electric charges. Theoretical study then suggested, first, that the electron was a disembodied charge of electricity without any material particle to carry it; and second, that it was a little bunch of waves. Finally, experiment indicated that an electron is a rather complex affair, behaving like either a charged particle or a group of waves, according to the experimental treatment to which it is subjected.

All this leaves us with the feeling that we know less today about electrons than we thought we knew when they were first discovered. This calls to mind a piece of wisdom uttered by a philosophical humorist of by-gone days—Josh Billings. He said: "It's better not to know so much than to know such a lot that ain't so."

But though we may know little or nothing about the ultimate nature of electrons, this has not prevented us from successfully putting them to work for us in many useful ways. For this purpose all that we need to know is how electrons behave under experimental conditions; and the more we learn about this the better able we are to predict how an electron will behave under conditions that have not yet been tried; and in this way important inventions have been made.

In almost all practical applications of electrons they are confined under control in tubes, and some 400 different types of tubes have been devised. All these types, however, may be grouped in three general classes. In the first class the electrons are set free by the action of light. In the second class this is accomplished by heat; and in the third class, called "cold cathode tubes," neither light nor heat is the activating agent. This latter class, however, requires a higher operating voltage than either of the others. To understand why there should be these three classes of tubes we must briefly review modern ideas of the mechanism of electric conduction in solids.

In all these tubes the electrons are set free from the cathode, and are of the negative variety. Their ultimate source is in the atoms which compose the cathode, the anode and, in fact, the whole electric circuit. Now an atom is a complex structure, containing a positively charged nucleus and a sufficient number of negative electrons to make the atom as a whole neutral. Some of these electrons are loosely held in the atomic structure, and under the push of an applied electromotive force may be passed along from one atom to the next, giving rise to what we call a current of electricity. This current is not a continuous stream, like water in a hose, but rather resembles the action of a "bucket brigade," where buckets of water are passed along from hand to hand. Urged by the electromotive force these mobile electrons move along through the conductor, colliding on the way with stationary parts of the atomic structure, and setting up atomic (and molecular) vibrations at each collision. The obstruction offered by the atomic structure to the motion of the electrons we call "electrical resistance," and the resulting molecular vibration "rise of temperature."

There is no sharp line of distinction to be drawn between good and bad conductors. The difference seems to be one of degree and not of kind. There may be two reasons for this difference. In a good conductor it may be that there are many loosely held electrons to start with; and it may be also that the constituent parts of the atom are grouped together in bunches, leaving comparatively large open spaces for the passage of the mobile electrons, and reducing the probability of collisions. In poor conductors it may be that there are fewer mobile electrons, and the atomic structure may be more uniformly arranged, with a

* *Numbers in parentheses indicate references given at end of Part 2.*

correspondingly greater chance of collisions.

With this picture of electric conduction before us we can visualize what happens in an electron tube when a voltage is applied to its terminals.

Under the push of the electromotive force the negative electrons in the cathode are urged along up to the gap between the electrodes, where they halt, reluctant to make the leap across. This halts the whole procession behind them. Similarly, in the anode the negative electrons are urged away from the gap. This results in a static charge at each electrode. At the cathode there is an excess of negative electrons, and at the anode the deficiency of negative electrons leaves the positive charge of the atomic nuclei in evidence. This process requires for its completion only a few millionths of a second after the voltage is applied.

For the hesitancy of the negative electrons in the cathode to make the leap across the gap there is an electrical reason. As each electron passes along through the conductor it moves, so to speak, in an atmosphere of atoms. Some of these atoms are neutral, and exert no disturbing effect on the electron; but others are positive, having given up some of their negative electrons to the current. These positive atoms exert an attractive effect on the moving negative electron, which may either accelerate or retard its motion, according as the electron happens to be moving toward or away from the atom. Statistically, taking into account the millions of atoms involved, these accelerations and retardations will cancel out as long as the moving electron is not too near the end of the conductor; but as it nears the end the retarding atoms behind it begin to outnumber the accelerating atoms before it, and at the very end there will be no accelerating atoms at all. If, as is usual, the electromotive force is insufficient to overcome the final maximum retarding effect, the electrons come to a halt.

To overcome this hesitation the electrons waiting at the gap need encouragement. One way of imparting this is to increase the push of the electromotive force. This is why cold cathode tubes require a higher voltage to operate them than is necessary for the other classes. Another way is to impart energy to the electrons as they move up toward the gap, so that they will keep up their speed and finally break loose entirely from atomic restraint. This can be done by supplying energy in the form of heat or light.

This, according to modern ideas, is the reason for the three classes of electron tubes. We shall now consider the action of these three classes more in detail, and first, the light-sensitive tubes.

The action of these tubes depends on the photo-emissive effect, which was discovered by Hertz in 1887(1). Maxwell's theory of electricity had been developed some twenty years earlier, but had not yet attained universal acceptance, as it lacked experimental confirmation. This lack Hertz was endeavoring to supply.

Hertz generated electric waves by the spark discharge of an induction coil, and received them by a resonant circuit containing a spark gap of adjustable length. For convenience in observing these small sparks he sometimes enclosed the resonant circuit in a dark box. He noticed that the sparks when enclosed in the box were shorter than when the box was removed. He then removed the box piece by piece, and found that the only part of the box that had anything to do with this novel effect was the piece that shielded the spark gap from the light of the spark of the induction coil. Further experiment showed that it was the ultra violet portion of this light that in some way was responsible for the lengthening of the spark in the resonant circuit.

Later experiments by other workers, after the discovery of electrons, showed that light would cause illuminated metals to emit negative electrons, and that it was the presence of these electrons in Hertz's spark gap which rendered the air more conducting and lengthened the spark. Much study was given to this subject, and it was found that the alkali metals were the most sensitive photo-electric emitters. In addition, these metals were found to have their maximum sensitivity within the visible spectrum, and therefore are most suitable for use with ordinary light.

In its essentials, a photo-tube contains two electrodes, the cathode being of a light-sensitive material. The tube may be highly evacuated or contain a trace of a gas purposely introduced to increase its sensitivity. Argon is commonly used for this purpose. Photo-tubes have found a great variety of applications, a few of which we shall describe.

In some places the law sets a limit to the density of smoke emitted from factory chimneys. The determination of this density by visual observation is at best uncertain, on account of the varying brightness of the sky, and at night such observations are impossible. A photo-electric smoke recorder has been devised which traces a curve for smoke density through all the twenty-four hours of the day. A beam of light is sent across the inside of the chimney from a lamp on one side to a photo-tube on the other. The current from the tube, amplified to the necessary extent, operates the recording instrument.

In some applications of photo-tubes it is advisable to adjust the color-response curve of the tube to meet special requirements. This can be done by a proper choice of cathode material, aided if necessary by color filters. One of these cases arises in the photometry of electric lamps. Here the color-response curve is adjusted to correspond as closely as possible to that of the human eye. For routine work in lamp factories

"Isn't it sad, Sir—civilians find that steaks are getting scarce. Do you remember what a steak is?"

an automatic instrument of this kind is found to be more rapid than visual observation, and to have the additional advantage of avoiding errors arising from human fatigue.

A more complicated case of the adjustment of the color-response curve may occur when the phototube is used for matching colors. It is well known that two materials which seem to be perfectly matched when examined in one type of light may appear different in tint when viewed in light of a different character. In the days before electric lighting was introduced, and when gas light was universal, it was found that silk dress goods purchased in the daytime might look very different when made up into evening dresses and worn under gas light. For this reason it was a common practice for department stores to have a special room where such goods could be examined and matched by gas light. However, two colored samples will appear the same in any light if their spectral composition is the same. By means of photo-tubes it is possible to compare samples by measuring the intensity of their three primary constituent colors.

The light reflected from one sample is passed through a red filter, and allowed to fall on a photo-tube. The resulting current is measured. The same is done with a yellow and a blue filter. The whole process is then repeated with the second sample. A comparison of the two sets of current readings will indicate the spectral composition of the colors of the two samples.

For the success of this process it is obviously necessary that the photo-tube should have a reasonably large response for each primary color. It may be impossible to obtain this with a single tube, and separate tubes with different mixtures of cathode materials may be necessary.

The action of electron tubes operated by heat depends on what is called thermionic emission, which was discovered by Edison in 1883(2). At that time Edison was working on the development of incandescent lamps, and had found that carbon was the best filament material then available. The inside of the bulbs of such lamps gradually became blackened, suggesting that there was a transference of particles of carbon from the hot filament to the glass. Usually there could be seen a less blackened line on the glass in the plane of the filament. This indicated that the detached particles of carbon did not fly around irregularly, but were shot off from the filament in straight lines. Electrons at that time were still unrecognized, but it seemed natural and reasonable that carbon particles shot off from the filament might carry with them electrical charges.

To test this, Edison constructed a lamp with a small metal plate between the legs of the filament, supported by a wire sealed through the bulb. He then made the filament incandescent in the usual way, and connected one terminal of a galvanometer to the metal plate. The other terminal he connected in turn to the positive and negative legs of the filament. He found that when connected to the positive leg the galvanometer showed a small current, but that when connected to the negative leg it showed, not a reverse current, but no current at all. In other words, a lighted lamp could be so connected as to act as a one-way conductor.

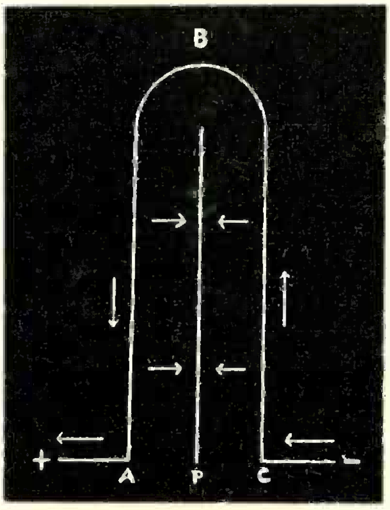


Fig. 1. Path of electrons to plate (P).

In 1883 this was a difficult phenomenon to explain. Edison patented it, but did no further work on it. With our present day knowledge of electrons the reason for this one-way behavior becomes clear.

In *Fig. 1*, ABC represents the lamp filament and P the metal plate. The filament is connected to the power circuit (which in those days was direct current) so that the left side is positive and the right side negative. These terms, it must be remembered, are purely conventional, representing eighteenth century ideas. They are, however, so well established that it would now create much confusion to attempt to change them. Actually, as we now know, the electric current is a procession of negative electrons moving from — to +, in the conventional sense of these terms, or in the direction CBA in the filament, as shown by the arrows. As is also shown by arrows, negative electrons are shot off from the hot filament toward the plate.

Suppose that a galvanometer is connected to P and A. Some of the electrons entering the filament at C will flow through the whole filament and leave by the point A; others will be shot across from the filament to the plate, pass out through the galvanometer and rejoin their companions at A.

If the galvanometer is connected to P and C, any electrons attempting to escape from the plate through the galvanometer will be met by others attempting to enter the galvanometer from C, and the result will be that no current will flow through the galvanometer.

This Edison effect, as it was called, came to the attention of J. A. Fleming, who at that time was connected with the Edison companies in London. He made many experiments on the subject, but it was not until after the discovery of the electron that the explanation of this phenomenon was attained. By 1904 Fleming had recognized the possibility of using a hot-filament tube as a valve or rectifier in radio receivers. This invention, known as the Fleming valve, soon displaced the crystal rectifiers at first used in radio sets. The addition of the third electrode, or grid, to the Fleming valve by Lee de Forest completed the invention of the modern radio detector.

The grid is one of the most important inventions in electronics. The two-electrode Fleming valve acted as a rectifying detector, but the signals were so feeble that they could be heard only by means of telephone receivers, and by but a few persons at a time. The introduction of the grid made amplification possible. It is important, therefore, to understand the action of this device. First, let us see what happens in a tube without a grid.

The hot cathode is continually sending out negative electrons which are attracted to the positive anode, called the "plate," from its usual shape. These electrons travel through the tube very rapidly, but those that are absorbed by the plate are replaced by others from the cathode, so that at any instant there is an invisible cloud of negative electrons in the space between the electrodes. This produces what is called the "space charge." This negative charge exerts a repelling effect on the negative electrons leaving the cathode, and tends to set a limit to the rate at which the cathode can send them out. If in any way we could diminish this space charge without reducing the number of electrons in the cloud, this repelling effect would be reduced, more electrons would be emitted per second by the cathode, and the tube would transmit more current.

Such a diminution in the space charge is brought about by the grid. As its name indicates, it is a gauze of fine wires with open spaces between them. If the grid is given a positive charge, it will partly neutralize the negative space charge and increase the flow of electrons toward the plate. Some of these electrons, of course, will be caught by the grid, giving rise to what is known as the "grid current." It is found, however, that this current is usually very small as compared with the plate current, which means that most of the electrons will pass through the open spaces in the grid and reach the plate.

If the grid is given a negative charge, the space charge will be intensified and the flow of electrons reduced. Some of them, however, will still pass through the grid and reach the plate. If the grid is made sufficiently negative, the flow of electrons may be stopped entirely. It is impossible, however, by further increasing the negative potential of the grid to cause the tube to transmit a current in the reverse direction as long as the plate remains cold and the cathode hot.

The characteristic curve for such a three electrode tube is shown in *Fig. 2*. It will be noticed that the curve is quite steep and nearly straight in its central portion. The lower bend of the curve terminates at the origin, and there are no negative values for the plate current. These peculiarities of the curve enable us to use the tube either as an amplifier or a rectifier.

In order to amplify an alternating voltage it is applied to the grid together with a steady voltage of such magnitude as to bring the fluctuating voltage up into the steep part of the curve. This, as may be seen by the diagram, converts the steady plate current into a direct fluctuating current. Because of the straight character of the curve in this region the average value of the plate current will be the same as its original steady value, but the fluctuation of this current—on a percentage basis—will be much greater than the percentage fluctuation of the voltage that was applied to the grid. This fluctuating plate current can be sent through the primary of a transformer and converted into an alternating current, which can be applied to the grid of a second tube and still further amplified.

If rectification without amplification is desired, the alternating voltage can be applied to the bend in the lower portion of the curve, where the unsymmetrical shape of the curve and the absence of a negative portion produce a rectifying effect.

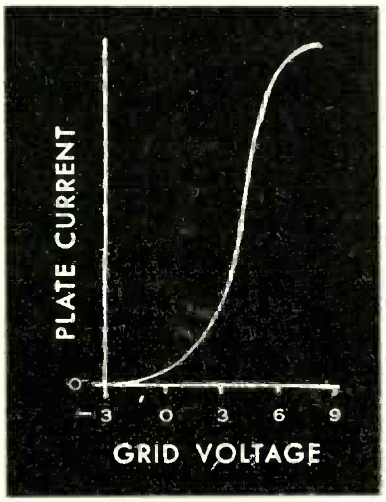


Fig. 2. Characteristic curve of 3-element tube.

The alternating voltage can be applied at any desired part of the curve by properly adjusting the steady voltage applied with it. This is the reason why tables of the constants of radio tubes give two values for the proper grid voltage, as a smaller voltage is required when the tube is used as a rectifying detector than when it is used as an amplifier.

The one-way transmission of electron tubes is now extensively used on a large scale in the construction of rectifiers for power circuits. In such applications the "tube" is a steel tank, and the cathode a pool of mercury. By means of an auxiliary anode close to the pool an arc is started, which produces a hot spot on the mercury surface. This spot serves as a focus from which electrons are emitted.

In addition to functioning as a rectifier or an amplifier, a three-electrode tube can be used as a generator of oscillating currents. Some practical applications of such currents, as in the induction furnace for the melting of metals, require frequencies higher than can be conveniently obtained by rotating mechanism. For such purposes vacuum tube oscillators are convenient.

There are several types of such oscillators. One of the simplest is the feed-back type. As we have seen, a small alternating voltage applied to the grid will produce a much greater variation in the plate current. If we tap off a small portion of the plate current and feed it back to the grid, oscillations will be produced which, when once started, will continue even though the original alternating grid voltage be removed. The frequency of such oscillations is determined by the inductance and capacitance of the circuit. Frequencies over a wide range, from one to a million or more cycles per second, may thus be obtained.

Such oscillators are extensively employed in laboratory work when sound measurements are to be made. Pure tones in the audio-frequency range can thus be indefinitely maintained, while a tuning fork requires to be struck repeatedly at short intervals.

Hot-cathode grid tubes are probably the most widely used class. For this, their use in radio sets is a large factor, but their applications in engineering and in laboratory work are extensive and increasing.

The third class, cold cathode tubes, is historically the oldest class of electron tubes. Its original ancestor was the Crookes tube of the 1870's. The phenomena exhibited by these tubes led later to the discovery of electrons and of X-rays. As used by Crookes, the tubes were exhausted to a high vacuum, less than a millionth of an atmosphere, and the voltage for their operation was obtained from an induction coil. Modern cold cathode tubes may operate at much lower voltages. This is made possible by introducing a small amount of gas, such as argon or neon, into the tube. For this reason, such tubes are often called "gas filled." This term may be misleading, as the pressure in such tubes is usually less than a tenth of an atmosphere. The neon sign lamp is a familiar example of this class.

"We call this set "Field Wife" you listen but can't talk back!"

The operation of gas filled tubes depends upon the small amount of ionization always present in a gas. A gas containing no ions would be a perfect insulator, but this condition never actually exists, as cosmic rays, photo-electric emission and other ionizing agents always provide a trace of ionization to start with. When a voltage is applied to the electrodes the negative electrons in the gas are drawn to the anode and the positive ions to the cathode, giving rise to a momentary current flow. This current, however, will not be self sustaining unless the voltage is high enough to give the electrons sufficient velocity to enable them to produce additional ionization by collision with the gas molecules. Collision of the positive ions with the cathode may also furnish electrons by secondary emission.

Each secondary electron, in its turn, may cause additional ionization. When the voltage is so high that each initial electron produces, on the average, more than one secondary electron, the current continues to increase without any further increase in voltage, and the tube breaks into a discharge which is limited only by the impedance in series with the tube.

These fundamental principles of the action of the different classes of tubes, and other properties of free electrons which we have discussed in the earlier lectures, have been combined in many ways to produce types of electronic apparatus for special purposes. One such type which well illustrates this combination is the cathode ray oscilloscope.

This instrument makes visible on a screen the wave shape of an alternating current. This shape, in practice, is seldom the smooth sine curve familiar in theoretical discussions; harmonics are usually present which modify the curve into various complicated shapes. A knowledge of this wave form is important in developing the design of alternating current apparatus, and the oscilloscope is a convenient instrument for obtaining this information.

In the oscilloscope, a beam of electrons is emitted by a hot cathode and attracted by an anode which has a hole in its center. Some of the electrons pass through this hole and strike a fluorescent screen placed at a little distance beyond the anode. Before reaching the screen the electrons pass between two metal plates. If an alternating voltage is applied to these plates the electron beam will be deflected up and down, producing a vertical line of light on the screen.

In order to spread this line of light out into a curve a second pair of deflecting plates is provided, arranged at right angles to the first pair. If we impress upon this second pair of plates a voltage which increases linearly with the time, the vertical oscillation will be drawn out

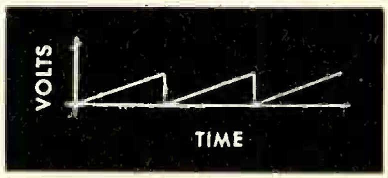


Fig. 3. Saw-tooth curve of electron stream.

into a curve; but the trouble is that the moving spot of light will soon leave the screen and never return. This difficulty could be overcome if the voltage on the second pair of plates could be made to rise linearly for one or two complete periods of the curve (or as many as the screen will hold) and then snap back instantaneously to zero and begin to rise again. This would require the second voltage to have a curve of a saw-tooth form, as shown in *Fig. 3*. In practice, means have been found to obtain so close an approximation to this desired form that the eye cannot perceive any change in the continuous wave form on the screen. The circuit for this purpose is rather complicated, containing sometimes as many as eight electron tubes, together with an array of satellite capacitors and resistors.

The beam of electrons in an oscilloscope is to all intents and purposes massless, and can be made to vibrate at frequencies far higher than would be practicable with any mechanical device. This is made use of in television apparatus.

In television work it is necessary to scan the object to be transmitted (and also the screen at the receiving end) with a set of parallel lines, perhaps a fiftieth of an inch apart. In addition, it is necessary that the whole area should be covered by this set of lines in not more than a tenth of a second. No mechanical device could do this, but a beam of electrons, properly focussed, will accomplish it with all the perfection required for the production of a good picture. As to the focussing of electrons, we shall have more to say about this in our next lecture, which will treat of the recently developed field of electron optics.

Another illustration of combination of fundamental principles is found in the application of electron tubes in electric welding. In this process the two parts to be welded are held together at high pressure, and a heavy current is sent through them. This pressure takes the place of the hammer blow of the blacksmith, and brings about a close union of the two metals after they have reached a plastic condition. The current is turned on after the pressure is applied, and off before the pressure is released. This prevents spattering of the metal and burning of the electrodes. The time during which the current is kept on is an important part of the operation. If this is left to the operator, there will be cases where fatigue of attention will spoil an expensive piece of work. Automatic timers have been devised in which electron tubes play an important part.

These electric timers have something about them which suggests the water clocks of antiquity. Imagine a large reservoir full of water, with a very small outlet at the bottom controlled by a stop-cock. When this outlet is first opened the pressure may force the water out at a fairly rapid rate, and the water level will fall with comparable rapidity; but as times goes on and the pressure lessens, the rate of outflow will diminish and the level will fall more slowly. In other words, such a water clock cannot maintain a constant rate. The longer it runs the more slowly it goes, and it cannot measure a long interval of time with the same accuracy as a short one.

Now consider the electrical analogue of this water clock—a capacitor charged to a high potential and allowed to discharge through a high resistance. The potential of the capacitor will fall like the water level, rapidly at first, but more slowly as time goes on, and complete discharge would require theoretically an infinite time; but the time taken for the potential to fall to say, half its initial value might be determined with fair accuracy.

Suppose the positive side of the charged capacitor to be connected to

(Continued on page 31)

SERVICING "PHILCOPHONES"

by Willard Moody

★ The Philco intercomm system, known as the "Philcophone," was distributed widely, and provided offices and industrial plants communication between remote points, establishing a high order of business efficiency. Like any other radio device, these units occasionally had service troubles. Most breakdowns centered around defective tubes, particularly the output and rectifier tubes. In some cases it would be found that the output tube would reach a very high temperature after the master station was turned on for several hours and that the reproduction would choke up. This was often due to grid current flow as the result of gas within the 25A6 and could be lessened in severity if the grid circuit resistance was changed to 250,000 ohms and a .01-mf., 600-volt or 1000-volt condenser was placed between the grid and the preceding 6K5 plate.

Over-heated Resistors

It was also commonly noticed that the resistors marked *20* on the diagram, *Fig. 1*, would overheat and blister. Drilling some vent holes in the bottom of the cabinet and placement of the master station reasonably distant from a wall would help this condition. Condenser *5A* on the diagram often developed an intermittent leak and the unit might cut off suddenly—and then be all right—before you could find the defective part. To eliminate this it was found by experience to be a good rule to replace the condenser whether it seemed to be all right or not, and then to let the unit run for a couple of hours to get thoroughly warmed-up. If it didn't cut off then, it was a safe bet it would be all right, and operate properly.

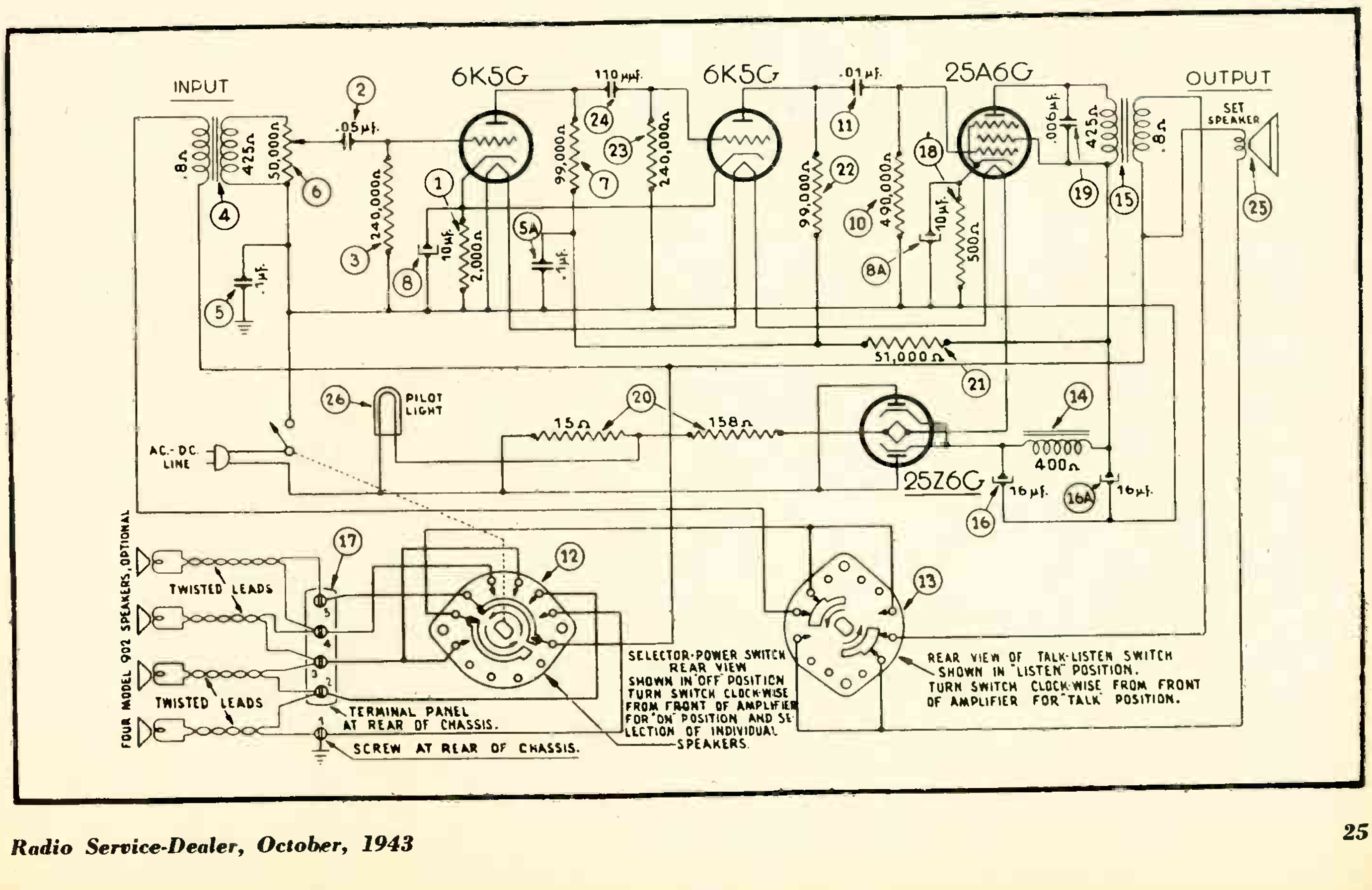
Hum and Fading

An intermittent hum was often due to a defective condenser (marked *5* on the diagram). Replacement (checked by the substitution method) was the best test, although in some cases you would merely find a poorly-soldered connection to the chassis was the cause of trouble. Slow fading was a condition, often caused by defective filters, which was simple to check and remedy.

In taking the unit out of the cabinet, it will be found that the wires to the speaker in the master station are very short making it rather difficult to work on the chassis. A short piece of 2-wire cable may be added and tucked out of the way when the chassis is put back in, or you can use an extension cable with alligator clips for doing the job and making the connections on the test bench.

This is an audio system and noise is not as pronounced as in the r-f

Fig. 1. Circuit diagram of Philcophone Models 901 and 902. The most common breakdown sources are described in the text.



types of interphone. Nevertheless, if the cables are run any appreciable distance it will be found that noise can be picked up, particularly in large cities where d.c. elevator motors and other machinery interfere. And speaking of interference, it was once found on the 23rd floor of a Manhattan office building, one mile from the transmitter antenna of the television station atop the Empire State building, that the sound portion of the television, on a very high frequency, about 50 megacycles, was being picked up directly by the second 6K5G and being rectified. The trouble was eliminated when the shield of this tube was cleaned with sandpaper and pinched slightly at the base to assure firm contact and proper shielding. Other remedies, including elaborate r-f chokes and filters on the cables and the power lines, and even r-f bypass condensers from grid to ground on each stage, had all failed. This was an unusual case but instances are on record of many similar cases.

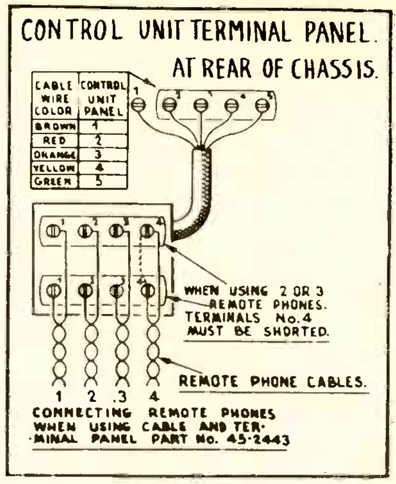


Fig. 2. Hookup method for 1 to 4 remote phone units. Part 45-2443 may be used to permit concealing the remote phone cables at the Master unit. Terminal 4 must be shorted when 2 or 3 remote units are being installed.

Switch Troubles

The selector switch, after being in service for some time, is generally in need of cleaning. The job can be done by using a brush and carbon tetrachloride, being careful not to splash the solvent all over. A clean linen rag helps.

Other common troubles are those found in the audio systems of a.c.-d.c. sets . . . microphonic tubes, speaker cones off-center or warped and in need of replacement. This Philco unit uses p-m speakers so you need not worry about open fields, but the permanent magnets may attract filings of metal, and metal may get into the air gap and cause trouble. Therefore keep the test bench free of steel wool or similar material when working on these gadgets.

(Continued on page 37)

TUBES and BATTERIES

by San D'Arcy

★ With every passing minute the tube and battery situation becomes more ludicrous and lugubrious—ridiculous and dismal! The mess will probably not be remedied while certain men retain their present administrative posts. Without question there is in Washington rife incompetency or indifference to civilian set owner's needs, else the present sad state of affairs would not continue.

WERS Batteries

As covered in the current and previous *"RSD"* editorials, there has long existed a radio battery shortage, particularly in rural sections.

Rural newspapers may or may not have carried the brief Associated Press squib which appeared in New York City papers advising readers that 1000 New York and New Jersey WERS had been allocated, by WPB in mid-September, over 56,000 batteries "for auxiliary power to be used if electric power lines failed." The news must have gotten around somehow, for on October 4th WPB supplemented its original release by announcing that "more than 100,000 radio batteries which are the victims of 'shelf age' have been distributed to WERS."

It is common knowledge that radio batteries go dead due to idleness. That very fact should have induced WPB to authorize the release of the batteries to jobbers for resale to set owners long ago. Who was guilty of allowing batteries to rot when an acute need for them existed. And, having decided that the batteries should be released at long last, who was so callous to civilian needs as to divert the stock to WERS for mere auxiliary use? Such questions should be answered. The parties who have proven their incompetence should be removed from their positions.

Tubes

The October 8th bulletin issued by Nat'l. Electronic Distributors Ass'n., of which George D. Barbey is president, clearly shows that a mess has been made of the civilian replacement tube program, too.

Early this year WPB made plans for civilian tube production schedules, quarterly quotas to be fixed. During the first half of the year some tubes were produced, supposedly for jobbers to sell to service-dealers. Because of the priority situation practically none of these tubes reached civilian receivers although various WPB and OWI releases tried to give the public the impression that its needs were amply being attended to. Subsequently the time arrived when 3rd and 4th quarter allocations were to be made. Originally WPB allocated 1,700,000 of the 15 most critical types of home receiver tubes for these quarters, but this figure was cut to 1,400,000 and then again reduced to 1,000,000, where it now stands. In other words a million tubes were supposed to go to civilians during the last half of 1943.

As tube manufacturers' records indicate that about 1,000,000 tubes have been released for civilian use during the final half of this year, it becomes apparent that no further production is scheduled until after January 1st 1944. That is the way matters stand; unless relief is given, the tube shortage must get worse, not better.

Audio Amplifier Stage Repairs

(Continued from page 7)

coupling capacitors. Such capacitors may, however, make suitable by-pass capacitors even though the leakage may drop as low as 15 or 20 megohms. Below 15 megohms or so, even for by-pass capacitors, they should be discarded. Instead of replacing the audio coupling capacitor with a new capacitor if its leakage resistance is still in excess of 15 or 20 megohms, we may transpose it with another capacitor in the receiver having the same or nearly the same capacity and where the leakage resistance is not as critical.

In the RCA model 5X5 the .01 coupling capacitor between the first and second audio may be transposed with the .025 plate by-pass on the second audio as shown in *Fig. 7*. *C1* and *Rg* are in series across *Rp* and a large change in capacity of *C1* will alter the response of the amplifier. *Rg* should be altered in the opposite direction of *C1* by the same percentage. Thus, when we increase *C1* to .025 micro-farads we should decrease *Rg* to approximately 250,000 ohms.

As another example, let us take the Philco model 40-508 which uses a .002 micro-farad capacitor to couple the 7c6 first audio to the 7A4 phase inverter, and two .004 micro-farad capacitors to couple the push-pull 42 tubes. Both of the type 42 tubes employ .003 micro-farad plate by-pass capacitors that may be transposed with the audio coupling capacitors should their leakage become too low to serve as coupling capacitors. If one audio coupling capacitor should develop a leakage resistance even too low for by-pass purposes, the plate by-pass capacitor could be used for coupling capacitor and that plate could be left un-by-passed with little if any ill results.

It is to be remembered that a leakage of 100 megohms or less will render a coupling capacitor useless for that function while it will operate satisfactorily as a by-pass capacitor down to a leakage resistance of 15 or 20 megohms.

For those who are interested in further study of the condenser substitution, a study of the *"Technical Portfolio* section of RADIO SERVICE-DEALER" for *May* and *June, 1943* will prove to be of great benefit.

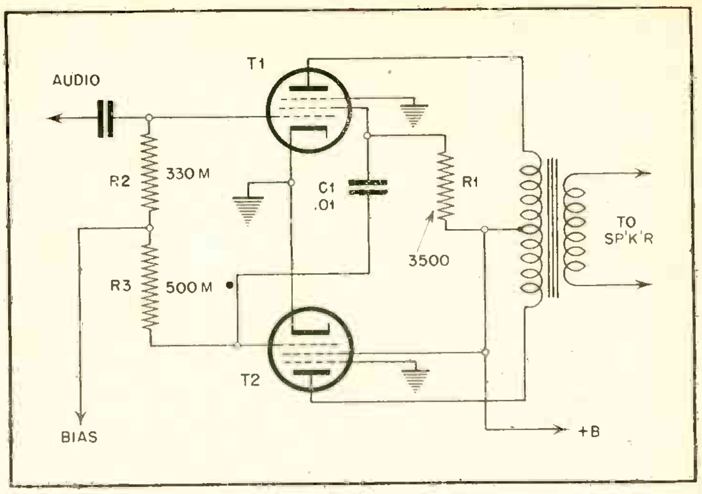


Fig 6. Push-pull output stage with no interstage transformer or separate ate phase inverter tube.

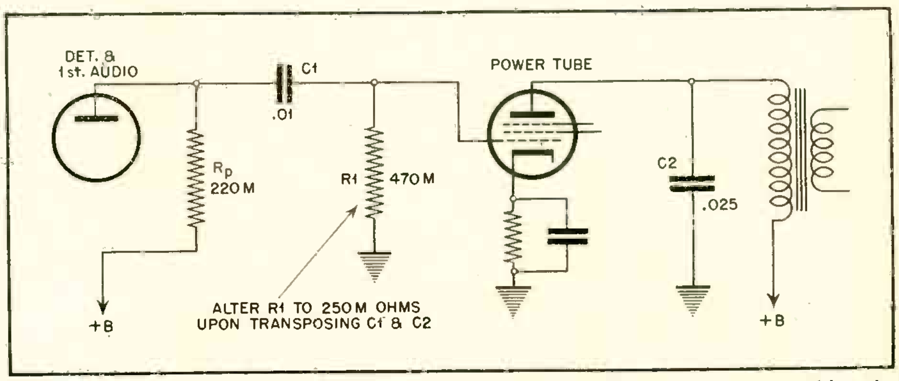


Fig. 7. C_1 & C_2 may be transposed if C_1 develops leakage resistance making it unsuitable for coupling.

ASSOCIATION ELECTS OFFICERS

The Association of Electronic Parts and Equipment Manufacturers, a trade association comprised of over fifty manufacturers of radio and electronic equipment located in the Middle West, honored its Executive Secretary, Mr. Kenneth C. Prince, Lieutenant (jg) in the United States Navy.

An election of officers for the ensuing year was held and P. H. Tartak, President of the Oxford-Tartak Corp. of Chicago, was elected Chairman of the Association. S. G. Shalkhauser, President of Radio Mfg. Engineers, Inc. of Peoria, Illinois was named Vice Chairman. Miss Helen A. Staniland, Vice President of Quam-Nichols Co. of Chicago, was re-elected as Treasurer. Lewis G. Groebe, associated with Lt. Prince in the practice of law, was elected Secretary *pro tem* and will perform the functions of Executive Secretary pending the return of Lt. Prince from active duty in the Navy.

Back row, left to right: J. J. Kahn, President, Standard Transformer Corp.; Lieut. Kenneth C. Prince; Paul H. Tartak, President, Oxford-Tartak Radio Corp. Front row, left to right: Lieut. Col. John M. Niehaus, labor officer, U. S. Army Signal Corps; Albert A. Epstein, Secretary, pro tem; Helen A. Staniland, Vice President, Quam-Nichols Co.

Shop Notes

Data presented as "Shop Notes", contributed by service-dealers as a result of practical experience, is carefully considered before acceptance. We believe it correct but we assume no responsibility as to results.

Card 1

IMPROVING UNTUNED OUTPUT I-F SETS

Many radios, (the G.E. M-50 being typical) employ an untuned output i-f transformer. These sets, in most cases, can be improved in volume, sensitivity, and selectivity if aligned as follows:

Connect sig. gen. output to grid of last i-f tube and rotate dial of generator to maximum output. Don't move the dial, but connect the generator to the grid of the 1st detector and align all other i-f transformers to maximum output. Align r-f and osc. stages as usual. This procedure may throw the set's dial readings out but the improved set performance makes up for it.

Submitted by J. E. Simmons

Card 2

ANTENNA COIL AND CHOKE REPAIRS

(Emergency Substitute)

When i-f coils go sour, short or burn-out, usually one section, either the primary or secondary, remains good, and this good portion can be used to replace the burned out primary of antenna coils—or small chokes.

Cut the good section off the defective i-f coil carefully. Connect it with a short lead to the unit being repaired. If necessary to move the coil lower or closer, insert a hot soldering iron in the end of the i-f, warm the wax so the coil can be slid down. Let cool so it will be in proper fixed position.

Submitted by Emmett E. Underhill

Card 3

RCA RE-45

(Phono Dead)

When two leads on a phono volume control cross, they will cause a short. By moving the leads apart and re-tightening the screws on the potentiometer, the trouble will be remedied.

Submitted by Willard Moody

Card 4

RCA V-170

Intermittent Oscillator

Radio picked up one station when not working (power local) which was due to a C-32, a 5600 mmfd. condenser in series with the oscillator tuning condenser. This fixed unit would open up on and off. Replacement cured the trouble. This was a tricky job.

Submitted by Willard Moody

Card 5

HUM IN AC-DC SETS

Some AC-DC sets hum badly on local stations. This condition can often be remedied by connecting the line bypass from the rectifier plate to cathode rather than from plate to ground.

Submitted by Spears Radio Service

Card 6

CONVERTING 6Q7 GT TO 6H4

6H4's are hard to get. By clipping pins #3 and 5 from the base of a 6Q7GT and disregarding the top grid cap you will be utilizing just one of the diode sections and the 6Q7 will give results as good as a 6H4's.

Submitted by George J. Pero

Card 7

MAKING SOLDER FROM SCRAP

Many bypass and filter condensers were made with tinfoil, particularly those used in Majestics and Grunows. The tin foil from defective capacitors can be removed and melted down carefully. Weigh cleaned tin. Re-melt and add 40% soft, clean lead for a 60-40 ratio, the best for average radio repair use. Be careful not to overheat or burn the mix. Cast into sheets 1/16" thick and cut into strips 1/8" wide.

Submitted by E. C. Entler

Card 8

REPAIRING LINE CORDS ON PORTABLES

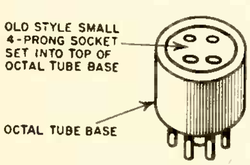
Many portables use a 535-ohm line cord; replacements are hard to get. By using a sharp pair of test prods, it is often possible to locate the break in the resistance wire. However, when the cord is beyond repair, a 40-watt light bulb may be used to replace the resistance element. Check the 35Z5 heater voltage, and if necessary, try a number of bulbs until one is found that comes close to giving the right voltage.

Submitted by Spears Radio Service

Card 9

WARTIME EMERGENCY TUBE ADAPTERS

Remove the glass and thoroughly clean out the base of an old 8-prong octal tube. Remove old leads from pins 2, 4, 6, and 8. Solder 3" long thin copper wires to each lug beneath an old type 4-prong socket. The leads from the 2 heater-prongs on the socket are pulled through the #2 and 4 pins—the leads from the socket's small prong holes are pulled through the #6 and 8 pins on the octal. Before pulling these leads tight and soldering them, cement the socket itself (with airplane glue or sealing wax) into the octal base. This adapter permits using a #80 rectifier in a 543 socket so no other rewiring is necessary. In similar manner, other tube substitute adapters can be made.



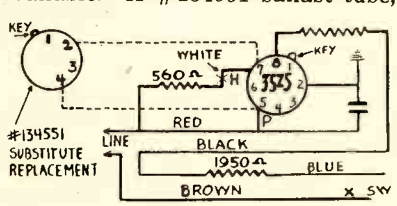
Submitted by E. C. Entler

Card 10

CROSLEY MODELS #27BD-E AND #43BT

(Line Cord Failure—Substitute Replacement)

For the duration no #130340 Line Cords will be available. A #134551 ballast tube, substitute replacement, properly wired in, must be used to effect repairs. Line Cord #130340 failure is usually caused by an "open" in the 560-ohm section. Using a #134551 Ballast, proceed as follows:



Remove white wire from lug #7 on 3525 socket (bottom view) and connect wire from #2 lug on ballast socket in its place. Then connect #4 lug of ballast to #5 lug on 3525 socket. No other connection need be disturbed.

—Crosley Service Notes

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TEAR OUT—MAIL TODAY

Electronics

(Continued from page 24)

the grid of a three-electrode tube. We saw in *Fig. 2* that when the grid is positive the tube may transmit a relatively large plate current, and that as the grid potential falls the plate current may diminish at a rather rapid rate. Suppose that the plate current holds an electromagnetic relay in the closed position against the tension of a spring, and in consequence a current flows through the weld. The tension of the spring may be so adjusted that when the grid potential falls to half its initial value and the plate current diminishes correspondingly, the magnet can no longer hold the relay closed. The relay then opens, and the welding current stops when the capacitor is half discharged. The greater the capacitance, and the higher the resistance through which the capacitor discharges, the longer the welding current will continue to flow.

In practice, the circuit arrangements are much more complicated than this, but the principle is fundamentally the same—the discharge of a large capacitance through a high resistance; and it is found possible to adjust the time during which the relay remains closed to any value from one tenth of a second to perhaps forty seconds with an accuracy sufficient for all practical purposes.

As another application, electron tubes are now frequently used in electrical measuring instruments. A typical instance of such an application is the vacuum tube voltmeter. Several types of such instruments are in use. The simplest type is the diode voltmeter, containing a two-electrode tube. The voltage to be measured is applied to the two electrodes of the tube with an ammeter in series in the circuit. The plate current, as indicated by the ammeter, will vary with the applied voltage, but not linearly, so that the instrument must be calibrated by applying known voltages.

When small voltages are to be measured a three-electrode tube may be employed, the voltage being applied to the grid. Here the amplifying effect of the tube comes in to increase the sensitivity of the instrument.

One practical advantage of the vacuum tube voltmeter over the ordinary electromagnetic type is its freedom from danger of being burned out by the accidental application of a high voltage. The vacuum tube instrument possesses a high resistance which is not produced by the usual coil of many turns of fine wire. It is true that the ammeter contains a coil, but this is not of the expensive type contained in the ordinary voltmeter, and moreover it has the resistance of the tube to protect it. As a result, the cost of an electronic voltmeter may be considerably less than that of an electromagnetic or electrostatic instrument of equal sensitivity.

These applications that we have described are only a few of the many ways in which electrons have been put to work since their discovery. Many more applications are described in the reference books cited at the end of this lecture. In these books circuit diagrams and more detailed descriptions are given. The field of application of electrons is by no means exhausted, and new applications are still being made; but the practical development of the subject seems to be nearing a point where all the easy things will have been done. From this point on, future progress in the subject will be made chiefly by those who have a good knowledge of fundamental theory, and a sufficient familiarity with the mathematical tools which these fundamental principles require for their development. An illustration of this, already at hand, is the recently developed field of electron optics, which has given us the important invention of the electron microscope.

There is much of human interest in the study of electricity, especially in its historical development from ancient times to the present; and it is of especial interest to note that the behavior of electrons when confined under control in vacuum tubes differs only in degree from their behavior in a flash of lightning.

REFERENCES

(1) Hertz: Electric Waves. The Macmillan Co., London, 1900. See Chapter 4, page 63.
(2) Crowther: Famous American Men of Science. W. W. Norton and Co., New York, 1937. See page 389.

REFERENCE BOOKS

Reich: Theory and Applications of Electron Tubes, (1934); Principles of Electron Tubes, (1941); McGraw Hill Book Co., New York.

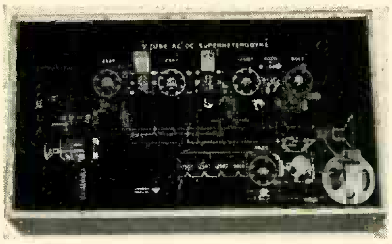
Gulliksen and Vedder: Industrial Electronics. John Wiley and Sons, New York, 1935.

Henney: Electron Tubes in Industry. McGraw Hill Book Co., New York, 1934.

Part III. of this article, *"Electron Optics,"* will appear in next issue.

DEMONSTRATOR BOARD

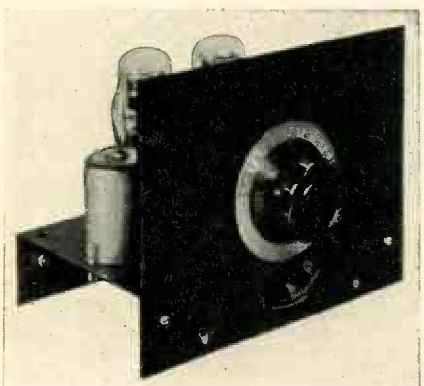
This 5 tube AC-DC Superhet Demonstrator Board is a most valuable aid in radio and physics classroom training programs and for lecture demonstrating purposes. It is laid out schematically in bread board style with actual radio parts mounted in position for quick removal and replacement to demonstrate function of each part in the circuit. Terminals are provided at all tube elements for measurement of voltages and signals. Jumpers are provided to open condenser, resistor and coil circuits and to short out these circuits wherever no damage will result. Schematic diagram is in color according to the R. M. A. code; grid circuits in green, plate circuits in blue, B positive circuits in red, and balance of circuits in black. Tubes are included. This and other training kits are offered by Lafayette Radio Corporation, 901 West Jackson Boulevard, Chicago, 7, Illinois and 265 Peachtree Street, Atlanta, 3, Georgia.



★

LAFAYETTE KITS AVAILABLE

Lafayette Radio Corp. of Chicago and Atlanta, is now able to offer radio training kits in quantity, to military and private training programs. The one and two tube regenerative kits illustrated are designed to provide complete basic receiver training at the lowest cost.



The one tube kit, when assembled, demonstrates grid leak detector operation and the effects of regeneration on a detector circuit. With the addition of a minimum of parts an r-f stage can be added without redrilling the chassis or moving any component parts of the detector circuit. Alignment procedure can then be demonstrated in its simplest form. These kits may be operated either from power supplies or from batteries when proper tubes are used.

Basics Of Sound

(Continued from page 19)

tortion, although it does effect a reduction in harmonic distortion.

The formula for the new effective internal resistance (plate impedance) of the pentode or beam tetrode with constant current inverse feedback is:

New Plate Impedance (Effective) = Old Plate Impedance (per tube manual) + Amplification Factor of Tube (per tube manual) × Value of bias resistor or $R_O = R_P + \mu R_C$.

Using the values of our example, the new plate impedance becomes:

$$R_O = 20{,}000 + 50 \times 100$$
$$= 25{,}000 \text{ ohms}$$

Since this value is actually higher than the original plate impedance, the damping effect explained for constant voltage inverse feedback is not achieved.

Summary

In summary, the results of inverse feedback are:

(1) Reduction of harmonic distortion

(2) Greater stability

(3) Reduction of frequency distortion

(4) Reduction of sensitivity

(5) Reduction of noise

(6) Change in the effective internal resistance of the output pentode or beam tetrode.

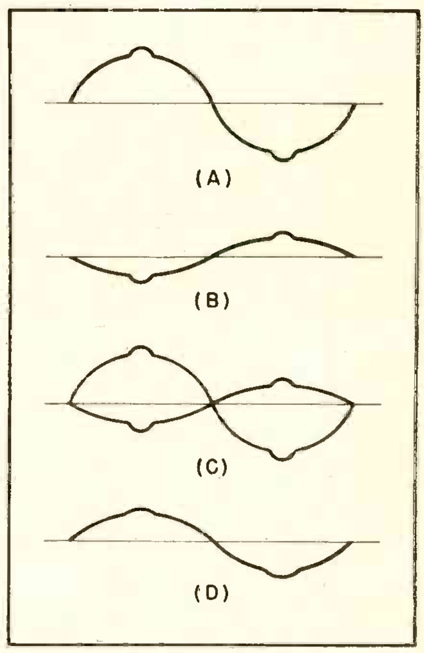


Fig. 6A. Wave shape without constant current feedback.

Fig. 6B. Wave form of voltage fed back out of phase with original voltage.

Fig. 6C. Combination of previous two wave forms.

Fig. 6D. Resultant wave form.

The serviceman should analyze troubles arising from inverse feedback in terms of the following:

(1) Inexpensive carbon resistors are easily affected by heat and may change in value, consequently changing the feedback ratio. This may cause either excessive feedback, resulting in decreased output or insufficient feedback resulting in increased output and poor quality depending upon the direction in which the feedback ratio change occurs.

(2) If C_B in *Fig. 3* is leaking, it acts as a resistor permitting a d.c. current flow through the feedback circuit, resulting in a voltage drop across R_F which "bucks out" or neutralizes the grid bias, producing poor quality and loss of output.

(3) Remember that amplifiers employing inverse

feedback require considerably higher overall gain because of the neutralization of the high gain of the pentode. The high power efficiency of the pentode is plainly of little value if distortion is high, and therein lies the full justification for inverse feedback.

(4) Feedback beyond two stages is generally unstable unless phase shift is reduced to a minimum.

If inverse feedback is impracticable for reasons of economy or size, the use of beam power tubes in push-pull is recommended as the best alternate. The characteristic of the beam power tube is such that third harmonic distortion is low, and second harmonics are cancelled out. As a result, the designer can obtain high power output with low driving voltage and little distortion.

Hum from poor filtering in the power supply is less pronounced in beam tubes without inverse feedback than in beam tubes with constant voltage feedback. This is due to the reduction in the effective plate impedance with feedback, which results in a greater voltage across the primary of the output transformer at the frequency of hum (60 cycles). Frequency distortion cannot, however, be controlled in push-pull amplifiers without feedback.

★

IRC PUBLISHES BOOKLET

An interesting booklet titled "Here's How" which contains Volume Control data has just been published by the International Resistance Co. Valuable information is also given on the figuring of resistor substitutes; formulas for guiding wattage; current and resistance values; a listing of preferred ranges; a Standard RMA Color Code chart, and a cleverly devised Resistor Determination Chart.

A free copy can be obtained by writing to the above company at 401 N. Broad St., Philadelphia, Pa. Dept. R.

POST-WAR ACTIVITIES

Raytheon Products Corp. post-war planning committee held a meeting in Chicago to plan extensive post-war activities.

The meeting was attended by E. S. Riedel, A. E. Akeroyd, F. E. Anderson, Fred Simmons, and Russ Lund.

★

RALPH CORDINER PROMOTED

Appointment of Ralph J. Cordiner as Assistant to the President of General Electric Co., has been announced by Gerard Swope, President.

Mr. Cordiner was, until June, Vice-Chairman of the War Production Board, prior to which he was manager of the appliance and merchandise department of General Electric Co.

★

GOVERNMENT SAVES MILLIONS

The government is saving incalculable millions of dollars in royalty payments on radio patents as the result of a plan proposed to the Signal Corps in 1941 by Commander E. F. McDonald, Jr., president of Zenith Radio Corporation of Chicago. Under this plan, which has been accepted by all but three or four of the country's manufacturers of radionic equipment, each company has granted the government a free license for the duration of the war under all patents it owns or controls.

★

TINS OF PHONO NEEDLES

Recoton last month announced the availability, to dealers, of a limited number of tins of their Concerto Phoneedle. The tins, which contain 200 needles, may be used for refill purposes on future purchases of standard 30-needle packages.

★

Servicing With Lamps

(Continued from page 16)

of the circuit (the left section in *Fig. 4*) which will produce the effects of a full short-circuit. These are C49 and C50. In other words, there are no resistors in series with them and the B+ feed line. If either one of these or other similarly connected condensers in other receivers develop a short the effect is the same as shorting the output of the power unit. Under this condition, of course, the test lamp will glow to full or almost full brilliance. However, when the suspected condenser is disconnected, the lamp will decrease in brilliance thereby proving the condenser was short-circuited.

Part 3 of this article will appear in next month's issue.

Servicing "Philcophones"

(*Continued from page 26*)

The volume control occasionally goes bad and may cause intermittent operation or noise. The leads on the back of the unit are apt to snap off and the screws may be strained and loosened. This can be avoided if pairs of wires are soldered together and taped, and then a single flexible wire is brought to the terminal in each case. The cable should be mounted out of the way and secured if possible, particularly when the unit is mounted on a shelf or on a desk where it might be pulled off and fall to the floor. In some restaurants the units are used in the kitchens. Where the original installation has been too close to a fire or greasy fats, the unit operates in faulty fashion. Relocation is often a means of bettering the service and reducing breakdowns.

Various connections to help you hookup any required number of remote units are shown in *Fig. 2* and *Fig. 3*. Only twisted 2-wire cable should be used for the runs between remote units and main control unit. Close proximity to unshielded power wiring should be avoided. The color code of the terminal panel wiring is given in *Fig. 2*.

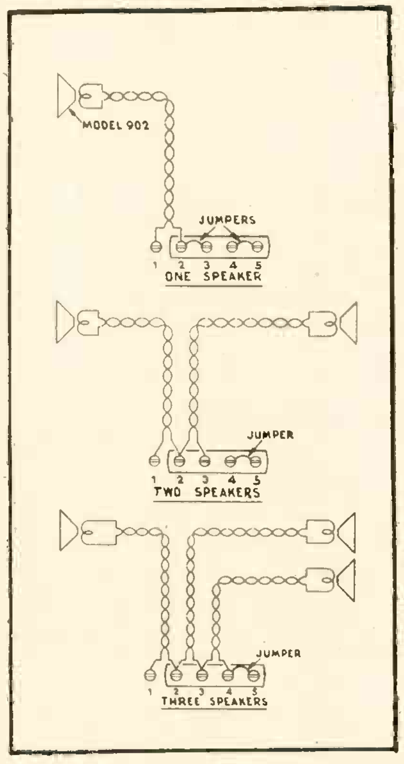


Fig. 3. Proper voice wiring plan for 1 to 3 remote-unit installations. Use of jumpers is determined by the number of remote stations involved.

Browne Cautions Jobbers

★ The Manufacturers' mad scramble for adequate representation by the nation's jobbers has already started, according to Burton Browne, head of the radio specialist advertising agency of the same name in Chicago. Since the war has brought many *so-called* new firms into the radio fields, it will not be a matter of having merchandise on your shelves, it will be *whose merchandise,—what lines* to carry,—and what the public will be expecting. Already the biggest companies have been making extremely detailed surveys. It will be just as bad to have the wrong lines in your store as it now is not to have any at all. Browne said further that while he must of necessity keep what he had seen confidential,—(and he admitted that he had seen much of Post War Radio),—nevertheless, he urged all jobbers to "go slow" in signing up with "new" manufacturers until each jobber had had a chance to look over the field and to weigh the advantages and disadvantages of the new line. Unquestionably, some of the new lines would be world-winners. But some might just bring grief. Until the Post War Situation jells, any attempt to tie oneself to any particular line to the exclusion of any other might result in disappointment. Patience would be rewarded by a line of sets and parts which would be well advertised,—creating customer demand, and would be sufficiently advanced to meet all competition in design. Such radios are even now on the drawing boards of most of the big concerns. When pressed to give

Burton Browne

a version of what was to come, Browne said to watch for transparently lighted cabinets, by-aural depth sound reception, and 4-way combos (recording, playback, phono, radio). Prices would be highly competitive and will start low, running into several thousands of dollars.

★

$2,500 IN WAR BONDS ROUTS LAY-OFFS AT KEN-RAD PLANT

One hundred War Bonds, of $25 denomination each, given to Ken-Rad Tube & Lamp Corporation employes for perfect attendance records, is proving highly effective in routing unnecessary lay-offs, the Owensboro, Kentucky plant reports.

The plan is a simple combination of record plus recognition. Ken-Rad employees, having a 100 per cent attendance record, are eligible for the "bank night" drawing. A large basket is placed in each division of the company. In this basket are placed cards containing the names of all department employees. Cards are drawn from this basket by blindfolded spectators, and as each name is called, the attendance record of that person is checked, immediately. If his or her record for the month is not perfect the name is discarded and another drawn. Selections continue until all bonds for the particular department have been awarded—the winners being the persons who have 100 per cent attendance records whose names have been picked from the basket containing all the names of department employees.

Jay Gregson, blind inspector, assisted by L. E. Septer, assistant Sales Manager, is selecting a card from the basket containing the names of all employes in the Transmitting Tube Division of Ken-Rad. John N. White is broadcasting the "bank night" and looking on are Berkley Davis, assistant works manager, and two judges, Miss Lauline Wimsatt, left, and Martha Sacra, right.

The one hundred bonds are divided among the departments according to the number of employees in each, both day and night shifts, so that each person has an opportunity to win a bond. The plan is not a lottery, since no "chances" are sold, and is a development of a previous contest in which teams competed for attendance honors and rewards in war saving stamps.

Moving Soon?

Notify RADIO SERVICE-DEALER'S circulation department at 132 West 43rd Street, New York, 18, N. Y. of your new address 2 or 3 weeks before you move. The Post Office Department does not forward magazines sent to a wrong address unless you pay additional postage. We cannot duplicate copies mailed to your old address. Thank You!

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

RADIO SERVICE-DEALER, Soundman & Jobber, published monthly at East Stroudsburg, Pa., for October 1, 1943.
State of New York } ss.:
County of New York }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Sanford R. Cowan, who, having been duly sworn according to law, deposes and says that he is the Business Manager of RADIO SERVICE-DEALER, Soundman & Jobber, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

That the names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, Cowan Publishing Corp., 132 W. 43rd St., New York 18, N. Y.; Editor, S. R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.; Managing Editor, I. R. Lush, 71 Ocean Parkway 18, Brooklyn, N. Y.; Business Manager, S. R. Cowan, Brooklyn, N. Y.

2. That the owners are: Cowan Publishing Corp.; 132 W. 43rd St., New York 18, N. Y.; and Sanford R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock, and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) SANFORD R. COWAN, Business Manager.

Sworn to and subscribed before me, this 17th day of September, 1943.

(Seal.) RAY F. WIESEN, Notary Public.

Kings County, Kings Co. Clk's No. 208, Reg. No. 4245, N. Y., N. Y. Co. Clk's No. 694, Reg. No. 4-W-398. Commission expires March 30, 1944.

Cover Picture

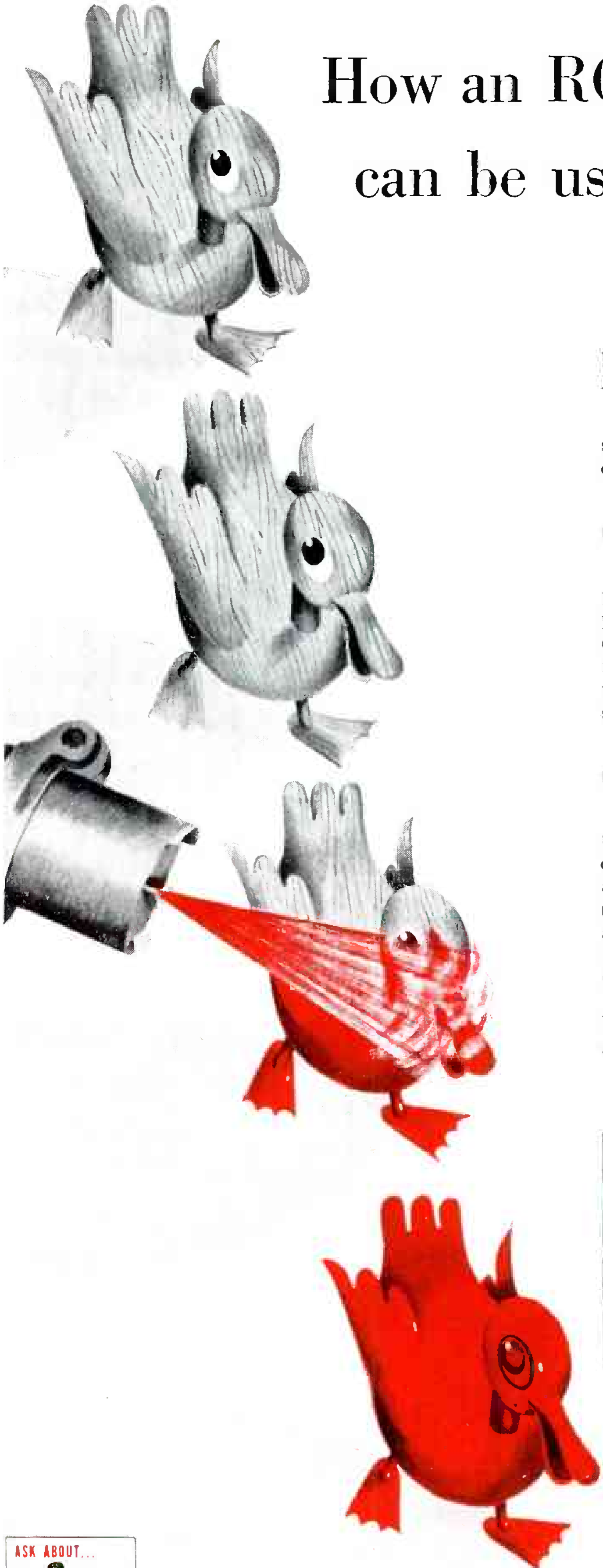
CAPTURED MESSERSCHMITT RADIO

Photo Courtesy Lear Avia

An engineer removes the radio receiver from a captured Nazi Messerschmitt 109. Examination shows that the set weighs about 60 lbs.; the design is about 10 years old, and obsolete; frequency range 2500-3700 kc by means of a 5-tube superhet circuit. Most components and parts are made of ersatz material.

Ad Index

How an RCA Electron Tube can be used to save paint



It's been said that the Electron Tube can do more extraordinary things than any other device yet created by man.

And we don't mean the wild-eyed, sleight-of-hand sort of thing so many people have in mind when they talk about "The World of Tomorrow."

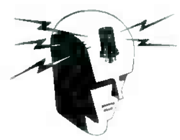
We mean cold, hard, practical things—like saving a manufacturer time and money—*today*, not day-after-tomorrow!

Pictured below, for instance, is a device used by RCA to save paint while spraying metal tubes. A conveyor carries the unpainted tubes in front of two spray guns and on into the baking oven. A control mechanism, built around an electronic switch, makes certain that the guns spray each tube completely but withhold the spray if, as occasionally happens, two or more successive tubes are missing from their sockets.

The principle behind this device can be used by any manufacturer who is interested in paint-spraying economies.

When you Distributors and Servicemen consider the opportunities the Electronic Age can open up for you, keep two points clearly in mind. (*1*) The electronic equipment you may be selling and servicing will use circuits, tubes, and parts largely familiar to you because of your radio experience. (2) The Magic Brain of all electronic equipment is a tube—and the fountain-head of modern tube development is RCA. *RCA Victor Division*, Radio Corporation of America, *Camden, N. J.*

TUNE IN "WHAT'S NEW?" *Radio Corporation of America's great new show, Saturday nights, 7 to 8, E.W.T., Blue Network.*



The Magic Brain that operates this device (used in spraying RCA metal tubes) is itself an RCA Electron Tube—2050. By seeing to it that a minimum amount of paint was wasted against non-existent tubes, it justified installation costs within a very short time.

★ BUY MORE WAR BONDS

RCA ELECTRON TUBES


12,000 REASONS
FOR RAYTHEON'S REPUTATION!
RAYTHEON tubes are selected as original equipment by America's leading radio manufacturers. Cost is a factor . . . but consistent performance, RAYTHEON performance, outweighs any cost factor. The 12,000 highly skilled RAYTHEON employees are 12,000 reasons why the RAYTHEON tubes you select will give consistent performance . . . they are a quality product and RAYTHEON quality never varies.
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Los Angeles . . . New York . . . Chicago . . . Atlanta
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RADIO & TRANSMITTING
DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES FOR THE NEW ERA OF ELECTRONICS